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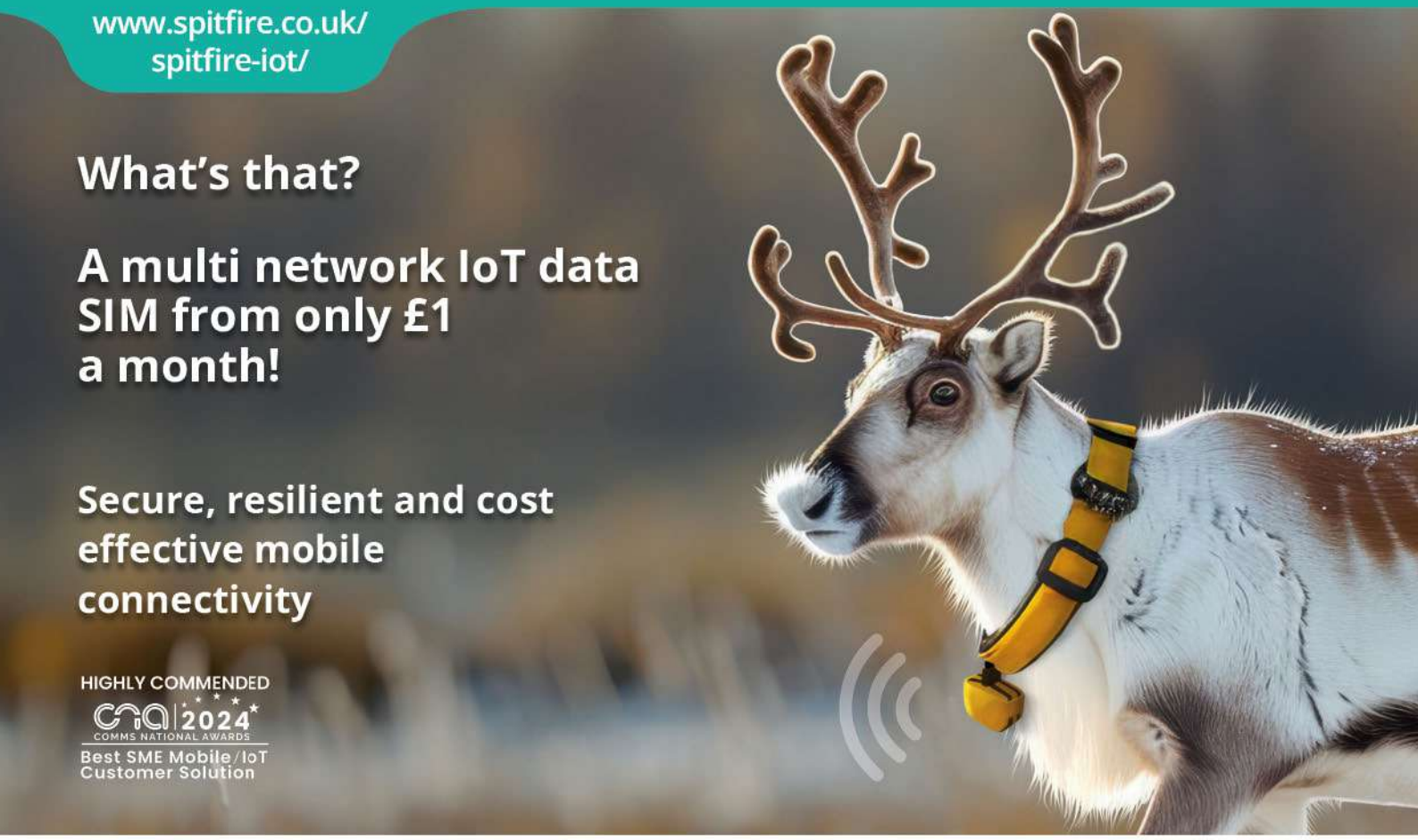

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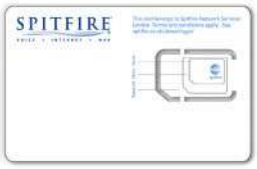

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Full contents overleaf

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HP OmniBook Ultra Flip

If you've resisted 2-in-1 laptops until now, the HP OmniBook Ultra might just change your mind. For one, it's a gorgeous and sleek laptop that packs a chip from Intel's most efficient Core Ultra 200V family. Even with a 14in OLED screen we found that it delivered such good battery life that we stopped worrying about charging it. But it also includes a terrific keyboard, and with a 1.3kg weight it's light enough that we were quite happy using it as a tablet when it came time to annotate PDFs. The only real question is whether it's worth the high asking price.

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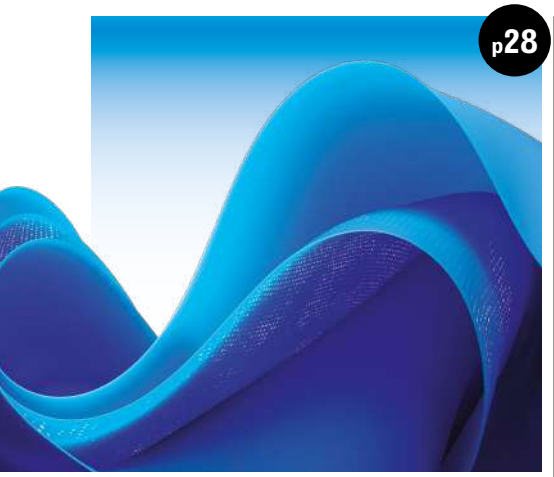

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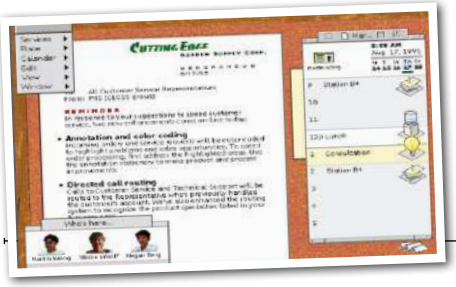
IBM ♥ Apple

People have now forgotten that Apple and IBM were very nearly bedfellows in the 1990s, with plans for an operating system to rule them all. We explain what went wrong – and why ultimately that was the best choice for both companies.



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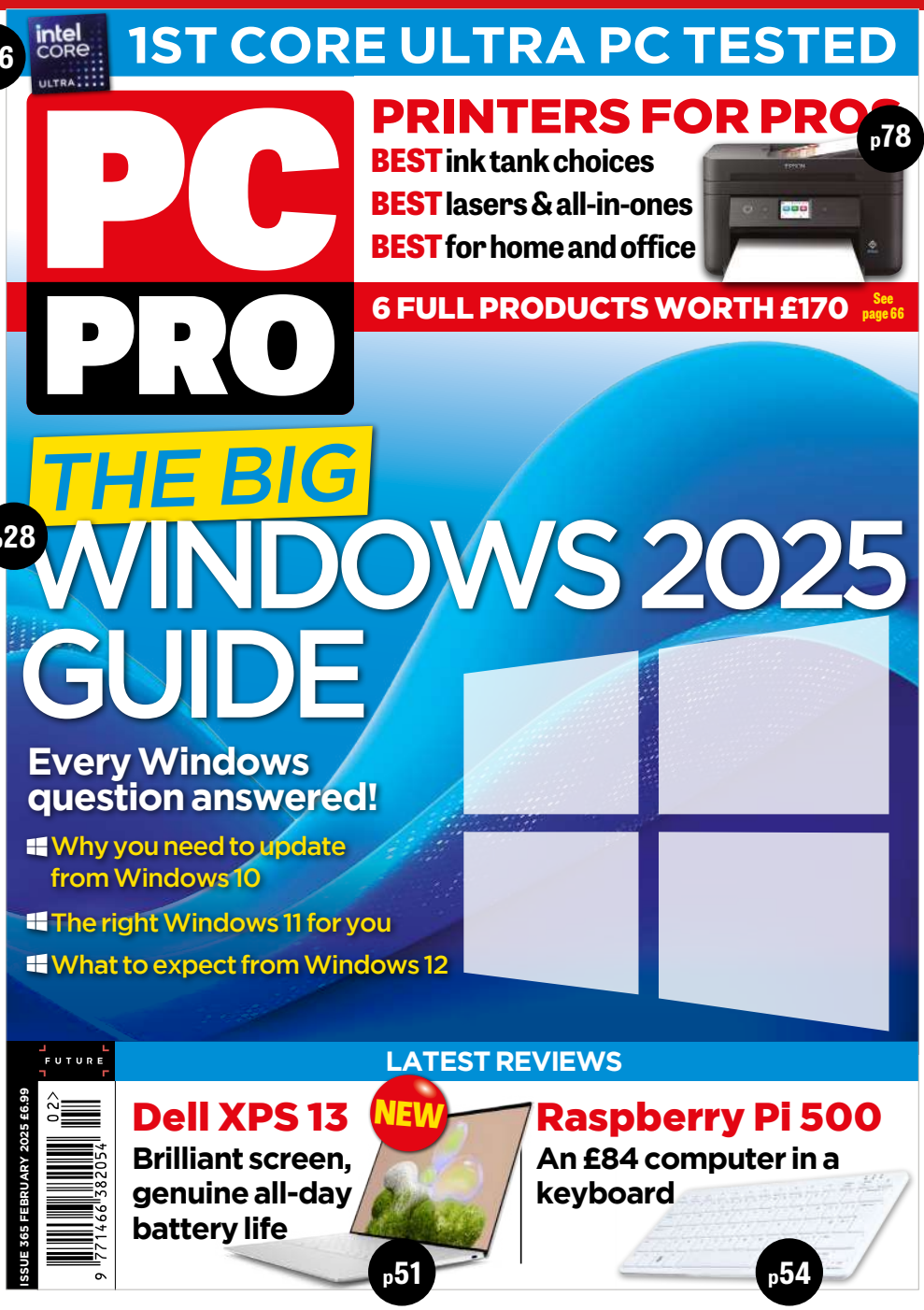

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It's time for radical honesty in the IT industry

I'll be honest: I haven't read Dr Brad Blanton's book *Radical Honesty: How to Transform Your Life by Telling the Truth*. In fact, the only reason I even know about it is because I asked Copilot if there was a philosophy of complete honesty, imagining that I would be directed to Greece in the 4th century BCE. But no, I was directed to this 21st century version instead.

My reason for searching is that I want to be more honest. To avoid the sugar-coating that sometimes creeps into my relationships, as I avoid telling people exactly what I think. A couple of my best friends have this attitude, and I know that others admire them for it – unless they're in the firing line. Why am I mentioning this? Because the IT industry could do with a dollop of honesty right now.

Take the departure of Pat Gelsinger from Intel, which we cover on p10. Even my cats know that he didn't retire. A blue-chip company does not announce the retirement of its CEO the day after that retirement was said to happen. That's a good old explosion in a boardroom, an irresistible force meeting an immovable object, and dammit I want to hear about it. But no, we receive a bland press release full of platitudes as Intel doesn't want to upset the market and Pat doesn't want to lose his $10 million golden handshake.

There's a similar nebulous cloud of mystery around AI, with manufacturers – including Intel – promising the world while delivering very little. In off-the-record conversations, everyone accepts that we're at the beginning of the mainstream AI journey. That in three decades' time, we'll look back at today's AI PCs with the same patronising nostalgia as we think of Amstrads and Commodores. But the marketing around these computers is so desperately trying to turn nuggets of usefulness into transformational technologies that will shake our world that they're destroying people's faith.

The thing is, we're not children. We know when we're being lied to – or, if "lie" is too strong for this magazine's lawyers, being fed a sugar-coated version of the truth. We want honesty. For example, I review the HP OmniBook Ultra Flip laptop this month (*see p46*) and it's a damn fine machine. HP's best for years, in my view.

But, unless Task Manager is lying to me, the AI Companion app it ships with barely touches the NPU inside – yet you can't use the AI Companion app unless you buy an HP laptop with an NPU inside. It's marketing. It's sugar-coating. I don't like it and it tarnishes my feelings for the computer, whereas if HP were up front about this then I wouldn't have a problem with it.

In contrast, I have only positive feelings about IBM having spent a day at its AI summit (*see p14*). Not because it was in Zurich – truth is, I saw nothing of Zurich – but because I was speaking to people doing real, cutting-edge research. It appears that if you have a PhD you have to tell the truth, and in great, molecular detail. My brain, which is a pea compared to theirs, was gasping for air by the time I left, but there really is great work going on here – and AI is key.

In one final moment of candour this month, I will admit I have no intention of reading Dr Blanton's book, despite its promise of "deeper connections and personal freedom". But, as with all the reviews and articles in this august magazine, I promise to tell the truth.

Tim Danton
Editor-in-chief

CONTRIBUTORS

Les Pounder
Les, who helped write and deliver the Raspberry Pi Foundation's teacher training programme, gives his honest verdict on five new Pi products this month, starting on p54

Simon Handby
We set Simon the unenviable task of testing 14 inkjet and laser printers to discover which deliver the ideal mix of quality, features and value. Read his verdicts from p78

Olivia Whitcroft
If you ask IP lawyer and data protection specialist Olivia for assistance, you can trust that she will keep your discussion confidential. But would you do the same? See p116

Barry Collins
What's Barry angry about this month? The demise of Western democracy? Cancel culture? The fate of his non-league football team? Nope: he wants a paper manual. See p24

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This month we asked our contributors: if you're brave enough, please make one tech prediction for 2025... See which won our popular vote with readers on p27

"In contrast to Nik, I think AI will mature to the point where most *PC Pro* readers will have their own AI agent – or agents – to help them perform work and home tasks more efficiently and effectively."

"OpenAI to enter death struggle with Musk, both explode (may destroy world economy in the process)."

"I think we could see Google open up and de-integrate its various products to a degree – partly for good competitive reasons, but also to avoid being completely broken up by regulators."

"Intel and AMD will announce their intention to merge the two companies before the end of the year."

"AI will prove to have been a flash in the pan. People will be tired of the 'hallucinations' and simultaneously get a green conscience about the environmental impact."

"Cryptocurrencies will become unusable as soon as Putin sues for peace."

"The *PC Pro* podcast will bag a trophy so shiny it might blind passing satellites. In response, a top global audio brand will shower us with fancy recording gear – our audio will be so crisp that ears will do a happy dance. Prepare for the transformation from 'muffled mysteries' to 'ear candy' that'll have you tuning in for more! Did someone say Patreon?"

"If Intel gets into deep trouble, is AMD likely to be able to supply the IA64 marketplace? Having Windows on Arm ready might be a good outcome, if anyone can be tempted to make WoA desktop hardware. And the Windows 365 Link (*see p33*) remote box will kick in big time on corporates."

"The threat of hybrid war will generate renewed efforts by nations to accelerate the adoption of cyber essentials to protect business and economic interests."

"People will still be getting tricked into clicking malicious links by someone saying 'please click this link'."

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Gelsinger's gone: what next for Intel?

CEO's departure raises prospect of company being torn apart

The abrupt departure of Intel CEO Pat Gelsinger leaves the beleaguered chip giant with an uncertain future, with increased speculation that the company's board may be looking to split the business in two.

Former Intel board members have called for the company to be cleaved in half: one part focusing on making chips, the other on chip design. Other industry analysts disagree, claiming Intel's board has made a serious blunder by effectively firing Gelsinger midway through his long-term restructuring of the firm.

All of this comes amidst the change of US administration, which threatens a huge government investment in Intel's ability to manufacture chips in the States. For Intel, the future could barely be more uncertain.

Early retirement

Intel attempted to paint Gelsinger's shock departure as a move into early retirement, but it subsequently emerged that the CEO was given an ultimatum: take the golden handshake or clear your desk. "The reality is this was not a retirement but a firing of Pat," wrote Doug O'Laughlin, president of semiconductor research specialists SemiAnalysis.

"His brief stint of 1,386 days was surprising because not only was he the most technically competent CEO of the last few bad apples at Intel, but he was also among the shortest."

Among the theories being offered for Gelsinger's sudden departure is a disagreement with the board over a restructuring of the company. The board, it's claimed, would prefer to split the company in half, spinning off the foundry business in the same way that AMD did when it established GlobalFoundries to take over the company's manufacturing operations in 2009.

That move was publicly endorsed by four former Intel board members in a joint piece for *Fortune* magazine, arguing that splitting the firm in two was "the only way to save America's most important manufacturer".

"Nvidia, Qualcomm, Broadcom, and others are desperate for a second manufacturing option to TSMC, but will remain hesitant as long as Intel directly competes with them," the quartet wrote. "Samsung, the only other advanced manufacturer of chips, has similarly discovered that many chip designers such as Apple and Nvidia tend to avoid its foundry because Samsung is a potential competitor."

"An independent foundry would offer open access to all American, Korean, Japanese, and European companies to accrete sufficient volume and ensure its commercial viability," they added, while admitting that the Intel design company would need to underwrite the foundry firm's losses "for several years" until new long-term manufacturing deals could be realised.

ABOVE Gelsinger's sudden departure throws Intel's whole future into doubt

LEFT Yesterday's men: Gelsinger with former President Joe Biden

> "It emerged that the CEO was given an ultimatum: take the golden handshake or clear your desk"

Long-time Intel watcher Ben Bajarin, the CEO of Creative Strategies, told *PC Pro* that a split now looks inevitable. "At this point, I think the general consensus is that what needs to be done," he said.

"In all actuality, I believe Pat felt this was the right plan also but only once [Intel] Foundry could stand on its own financially, which won't happen until the end of the decade. So, I'm not sure the schism with the board was over this specifically but perhaps more the timing of it."

However, O'Laughlin believes that following the AMD blueprints could be a fatal mistake. "I would liken firing Pat in the final hour of 18A [the company's new manufacturing process] to quitting the final round of chemotherapy in cancer treatment," he wrote.

"Instead of seeing the long and painful process through, I think the board will let Intel die and be sold for parts. It's the correct answer to maximise relatively short-term shareholder value, but it's a near-sighted move that the Intel board specialises in."

CHIPS on the table

The uncertainty over Intel's long-term structure comes amid further ambiguity over the future of the US CHIPS Act, which was set to invest heavily in Intel's domestic manufacturing facilities.

In November, it was announced that Intel would receive around $8 billion in federal grants to support semiconductor manufacturing plants in Arizona and Ohio. That comes on top of the $3 billion government contract Intel secured to manufacture chips for the US military.

But November also brought about a change in president, to one that has criticised the direct government funding of the CHIPS Act in preference to imposing punitive tariffs on semiconductors imported from Asia. The suspicion is that President Trump won't rip up the CHIPS Act – being one of the few pieces of recent legislation to have bipartisan support – but it's always tricky to tell where the rhetoric ends and the policy starts with an incoming administration.

Geopolitics might also convince Trump to keep subsidising Intel. "TSMC does have plans to keep building manufacturing facilities in the US," said Bajarin, but "Taiwan is against letting them develop their most leading-edge process on US soil, although this could still happen. The bigger point is that even if TSMC does this, it's still not a US company. Intel is the only hope of a US company making leading edge chip production in the US."

The identity of its leadership and ongoing government funding aren't the only doubts hanging over Intel at the moment. The company has been subject to ongoing takeover speculation, with Qualcomm, TSMC, Samsung and even Apple linked with potential bids for Intel in recent months, although none of the supposed suitors has made a formal offer at the time of writing.

Yet the fact that Intel is even being talked about as a possible target for rivals such as Qualcomm and TSMC shows how far the company has fallen. In mid-December 2024, Intel's share price was less than a third of what it was during the 2020 Covid peak, when companies were rushing to buy computers for home-bound staff.

> "Instead of seeing the long and painful process through, I think the board will let Intel die and be sold for parts"

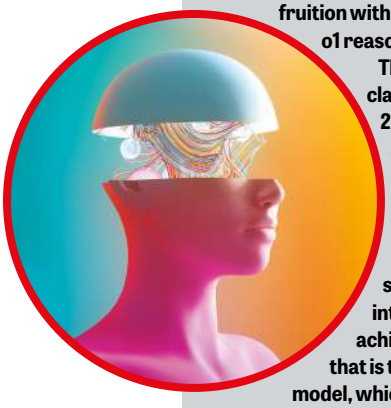
It's bleeding market share to AMD on the desktop and the highly lucrative server markets. When Microsoft launched its new Copilot+ PCs last summer, it did so without either AMD or Intel, preferring to launch with Qualcomm-based systems instead. The x86 products landed later.

Intel is vulnerable. What is does next might well decide whether it's rescuable or fatally wounded.

LEFT Intel's long and illustrious chip-making history could be nearing its end

AGI edges closer as o1 leaves preview

ChatGPT's new reasoning model is unleashed in full



BELOW AGI could be with us by the end of the year

Sam Altman's bullish claims that AGI could be achieved as soon as this year have taken a step closer to fruition with the full release of the o1 reasoning model.

The OpenAI CEO claimed in a November 2024 interview that artificial general intelligence, the point at which AI becomes at least as capable as humans across the full spectrum of intelligence, could be achieved in 2025. Key to that is the o1 reasoning model, which has been available in preview mode to ChatGPT Plus subscribers for the past few months.

The o1 model has been widely accepted as a step change in AI due to its ability to reason and problem-solve in a human-like manner. The full o1 model is significantly more intelligent than the preview version, Altman claims, and now comes in an even cleverer "pro mode" that will only be available to customers on ChatGPT's punchily priced and unlimited $200-a-month Pro plan.

OpenAI claims the new model is highly capable in maths, science and coding challenges. For example, the new "pro mode" would be in the 90th percentile for solving coding problems in the Codeforces tests, according to OpenAI. The o1 preview hit only the 62nd percentile.

The rapid rate at which the o1 model is evolving gives Altman confidence that AGI is not a distant goal. "We could hit some like unexpected wall or we could be missing something, but it looks to us like there's a lot of compounding still to happen," the OpenAI boss said in an interview with Y Combinator.

Altman isn't coy about predicting where this advanced AI could lead us, claiming it might soon be able to solve "every problem in physics" and avert an energy crisis by creating abundant power – handy for a technology that is consuming so much energy AI firms are investing in their own nuclear reactors.

"This is a point in time where whatever feels like abundant energy to us will feel like not nearly enough to our great-grandchildren, and there's a big universe out there with a lot of matter," Altman said.

The space race for your phone

T-Mobile has teamed up with Starlink to eliminate mobile dead spots in the US. Barry Collins investigates whether it could take off in the UK, too

If you're on the T-Mobile network in America, mobile not spots could soon become a thing of the past. Well, as long as you're outdoors, that is.

T-Mobile's tentative deal with SpaceX's Starlink service has won approval from the Federal Communications Commission (FCC), meaning that the vast swathes of the US landscape without any mobile signal will soon be serviced by Starlink's satellites. And you probably won't need a new phone to benefit, either.

The concept of improving mobile connectivity from space isn't restricted to large countries such as the US, which has huge holes in its coverage. In the UK, Ofcom is considering whether to permit similar services, even though 90% of the UK landmass is already receiving "good quality data and voice coverage", according to the regulator.

But before we start celebrating the end of "no signal" nightmares, let's explore the challenges that face delivering mobile signals from space.

Those familiar with Starlink's current service might be wondering how it's even possible for your everyday smartphone to connect to the company's fleet of satellites, given that you currently need a dish to access the service.

It's possible because the FCC has granted partial approval to operate 7,500 Gen2 Starlink satellites at altitudes of 340-360km, which will crucially send and receive signals in the 1,900MHz band. These frequencies are typically reserved for terrestrial cell phone services, and indeed Starlink is using a chunk of spectrum that is currently allocated to T-Mobile. Your common or garden smartphone is already compatible with that frequency range, meaning that where cell tower coverage isn't available, it can pick up a signal from the satellites.

The T-Mobile/Starlink partnership will initially be pretty limited, only allowing customers to send text messages when they're outside of cell tower range. In that regard, it's similar to Apple's Emergency SOS service, allowing people with no regular signal to send text messages to the emergency services, provided they have a modern iPhone.

However, the Starlink/T-Mobile partnership proposes to go much further, offering full voice and data services via satellite in 2025. The hope is that T-Mobile customers will be able to use their smartphone as normal wherever they are in the US, albeit with a clear line of sight to the satellites or some means of relaying the signal indoors.

Is Amazon plotting a UK mobile network?

Starlink isn't the only satellite provider with eyes on Low Earth Orbit. Amazon has long been promising to put up some competition with its Project Kuiper, although at the time of writing it had yet to deploy anything but prototypes.

That is set to change in early 2025, however, with Amazon preparing to make its first commercial deployments. And another indication that it's preparing to go live comes in the responses to Ofcom's consultation on Direct to Device (D2D) satellite services: while SpaceX didn't offer a response to the consultation, Amazon Kuiper did.

Amazon's response suggests it would rather not strike a deal with a mobile network to license already allocated spectrum, as Starlink has done with T-Mobile, but that it would rather go it alone, maybe offering a phone service to consumers by itself. It encourages Ofcom to "proceed in a broader and more sustainable manner" and to avoid creating an "unnecessary and multi-year hurdle for the next generation of D2D services seeking access in new ways and in different frequency bands.

"Amazon, therefore, urges Ofcom to encourage competition and innovation by broadly enabling D2D services across all frequencies allocated for terrestrial mobile services and all geographic areas, so long as applicants can demonstrate compatibility with existing terrestrial licensees."

Surprise, surprise, the mobile networks that responded to Ofcom all take a different view, arguing that the satellite providers should be forced to strike deals with the networks, or as Virgin Media O2 puts it, "a suitable licensing framework to enable the MNO to provide the satellite operator with rights to access the licensed mobile spectrum, in order to deliver the agreed service".

Satellite phone provider Lynk Global encouraged "Ofcom to be open to an MNO utilising more than one D2D provider to enable flexibility and maximise the benefits that could be realised".

ABOVE Not spots in the great outdoors could soon be a thing of the past

The obstacles

Although this all sounds like a marvellous way to reach people and areas that are never likely to be served by conventional cell towers because the economics just don't add up, there are potential problems with delivering a cell service from space.

First, by bringing the Gen2 satellites closer to Earth, there's the risk of interfering with other space objects, most notably the International Space Station. Although the Space Station is usually orbiting way above the new satellites, at altitudes of around 400km, satellites might cross the ISS's orbit during manoeuvres or deorbiting, raising potential collision fears. So one of the FCC's conditions for approving the new satellites is that Starlink must continue to work with NASA to minimise such risks.

There's also the growing risk of the satellites colliding with themselves in the increasingly crowded Low Earth Orbit, giving rise to fears of space debris clattering into the ISS or other spacecraft, or creating a cascading effect known as the Kessler Syndrome, where a chain reaction of multiple collisions renders Earth's orbit unusable.

The FCC's authorisation document stated that NASA had raised concerns "about the functioning of SpaceX's autonomous collision avoidance system, particularly at lower altitudes where atmospheric drag is higher", meaning that the satellites deteriorate more quickly. However, the report adds that "both NASA and SpaceX are confident NASA's assets can remain safe while sharing space with Gen2 Starlink, and neither NASA nor SpaceX have identified issues that cannot be resolved by continued coordination".

It's not only physical interference, but signal interference that poses another potential drawback. There's potential for interference with other mobile network services, due to out-of-band emissions (OOBE) from the satellites. Starlink has asked for a waiver from certain OOBE limits, which "all other commenters, with T-Mobile excepted" raised concerns about with the FCC. The regulator has deferred a decision on whether that waiver will be granted.

Radio astronomy, GPS services and emergency services frequencies could all be potentially affected by interference too, which means that other international regulators such as Ofcom will be keeping a keen eye on what happens when the service goes live in the US in the coming months.

Satellite mobiles in the UK

So what are the chances of Starlink or another satellite provider striking a similar deal in the UK? Ofcom is currently consulting with industry, but seems generally warm on the idea. "We plan to consult on specific proposals to authorise Direct to Device satellite services in mobile bands in the UK in early 2025," the regulator said in a report in November. "Subject to consideration of stakeholder responses and our final decisions this could enable such services to be offered to consumers later in 2025."

Ofcom's summary of responses from industry so far highlights potential advantages, such as improving access to emergency services in remote areas, enhanced resilience for mobile networks where satellites can be used as a fall-back option, and providing connectivity to those currently in the not spots.

However, there are question marks over the business case for such a service. With only 10% of the UK's landmass currently unserved, filling in those not spots is not going to suddenly bring millions of new customers to the networks. "I think it's quite difficult for operators," said Joe Gardiner, a research analyst with CCS Insight's telecom and connectivity research team.

"Will people pay for SOS capabilities on their phone? Very unlikely. The only time you'd pay for that is when you're actually in an emergency. SMS? I think in this country it's not used as much as it was. I think the real use case would be data, but... it's going to cost a lot of money to implement by the operator."

> "Will people pay for SOS capabilities? Very unlikely. The only time you'd pay is when you're in an emergency"

If networks do offer satellite services in the UK, Gardiner thinks it will arrive in the form of a "contract uplift", where the network will justify charging more for 100% UK coverage.

Gardiner warns there could be other unintended victims if Direct to Device satellite takes off here. "One thing to consider in the UK market is how... it's going to affect something like the Shared Rural Network and all the investment that's gone into that," he said. The Shared Rural Network is a project funded by the UK's four mobile networks and the government, to deliver 4G broadband to 95% of the country.

The advent of satellite telephony is "something that maybe the government didn't foresee at the time," when the agreement was reached five years ago, but it could jeopardise the entire project, Gardiner warns.

Yet, despite the technical challenges and other hurdles, both Gardiner and Paolo Pescatore, founder of PP Foresight, believe Starlink is likely to partner with UK networks to offer a similar service over here. "Ultimately for Starlink to broaden its appeal, it must partner with telcos," said Pescatore. "This will prove crucial in ensuring robust, reliable and more importantly ubiquitous connectivity for all."

4 surprising things we learned from IBM Research

While AI and quantum computing were the two big themes at this year's IBM Research Europe media event, Tim Danton reveals there was also one surprise lurking in the lab

Perched on a hill overlooking Lake Zurich, there sits a group of inauspicious buildings. This is the campus for IBM Research Europe, and inside you'll bump into some of our continent's brightest minds. Some of their research areas are predictable: artificial intelligence, quantum computing, integrated circuits. But it's also working on areas that might surprise you.

I was there for the faculty's annual media event, titled "IBM: Shaping the Future of Computing". Based on briefings, demonstrations and visits to the labs, this article focuses on four initiatives of particular note.

Understanding the Earth

On 6 December, the day before the event, IBM announced that – in partnership with NASA – it had released Prithvi-EO-2.0, an open-source geospatial foundation model. Such models are trained to recognise anything from cattle to water coverage to foliage; feed it satellite data and it will produce meaningful information without human analysis.

"The new model that we have is excelling at all these tasks to a point that [we can say] our models are the leading ones in this space," said Juan Bernabé-Moreno, director IBM Research Europe/UK & Ireland. "But what do we do with the models?"

The first example was all too topical, following the flooding in the Valencia region in late October 2024. "Here, the beauty of the model is it doesn't only work with Sentinel 2 data, so with images, it works also with radar data. The difference is with images only then when you have flooding, you have clouds, and if you have clouds, it's very difficult to understand the impact of the flooding. But… with radar data, you can look through the clouds and you see all the flooding."

Read our Cheat Sheat for more on post-quantum cryptography, p107

Next, Bernabé-Moreno explained how the same model could be used to understand the impact of a reforestation initiative in Kenya. Pointing to a satellite view, he said: "Let's divide this area in chunks, where [local people] are going to be incentivised if they increase their tree coverage ratio. And what you see here is that our model can measure the tree coverage ratio at a very general level." All of which allowed the Kenyan government to rapidly work out which incentive schemes worked best.

> "The new model… is excelling at all these tasks to a point that our models are the leading ones in this space"

Finally, Bernabé-Moreno covered how IBM had worked with partners such as the Linux Foundation to create a foundation model that helps remove the complexity and uncertainty in the electric grid. This will make it more efficient – which it will need to be, because some predict that by 2050 we will need to produce twice as much electricity to decarbonise the economy.

BELOW NASA and IBM have released a new geospatial foundation model

Cryptography: time to wake up

"If I told you, there is a 1% chance that this building is going to collapse in 20 minutes, what would you do?" A question posed by Jaime Gómez García, head of quantum at Santander Bank, who then looked out expectantly at the audience. "You would evacuate because you would be concentrating on the risk. Would you start discussing, is that 1% real, or is it going

to be a zero or 5%, or would you start discussing about is it going to be in 20 minutes or in one hour?"

We all know the answer, but the point Jaime was making is that this is where we are with cryptography in 2025. Quantum algorithms will break the cryptography foundations we've all come to rely on throughout our lives, the ones that underpin every transaction in our global economy, and the fact we don't know exactly when that threat will become real is irrelevant. We need to act.

"What is happening is that we are not concentrating on the risk, and so we are not creating the right programs to address the challenge," he said. Although it's worth pinning down who, exactly, he means by "we". Perhaps top of the list comes governments. While the US government is taking this seriously, explicitly telling anyone involved in providing services that they must meet quantum-resistant cryptography standards, the rest of the world has not been so blunt.

The next layer down are the infrastructure suppliers and organisations that are big enough to have an influence. If they are releasing code that doesn't meet post-quantum cryptography standards then they aren't meeting "first aid, 101" levels, in the words of Michael Osborne, CTO of IBM Quantum Safe (pictured above right). In other words, he said, organisations must "stop the bleeding".

So, I asked, what should smaller companies do? "Smaller organisations are more likely to just need to update their software and their products, following their providers," said García. "So your vendors are going to solve it for you, unless you do your own development." But, Osborne emphasised, we must all be aware of the risk.

ABOVE Jaime Gómez García (left), head of quantum at Santander Bank, in full flow at the event

Quantum computers are already "tools for scientific discovery"

IBM is one of the world leaders in quantum research, and Stefan Woerner, IBM's manager of quantum computational science, was keen to highlight that "quantum computers are now tools for scientific discovery" at the summit. In particular, IBM has proven via a paper published in *Nature* in 2023 that a "quantum computer with 127 qubits can run quantum circuits with 2,882 qubit gates and get meaningful results".

Why does this matter? "This pushes us into a regime that's far outside what we can simulate exactly with classical techniques. So... we could use this quantum computer to do things, to do calculations that you cannot do classically." Since this point, the hardware has advanced – in line with the detailed roadmap that IBM laid out a couple of years ago – and so quantum computers have become even more potent.

With this, Woerner says that we have entered "the era of quantum utility. We are not calling this the era of quantum advantage yet [which] is when we solve a practical relevant problem faster, cheaper or better than what is possible classically." Instead, quantum utility means they can use quantum computers to "advance algorithmic discovery, to try out new ideas that otherwise would not be possible".

So, what's happening next? By 2026, IBM aims to have created quantum circuits that are complex enough to solve these problems. In terms of numbers, that means going from 127 qubits to 156 qubits for one quantum core, bringing the total number of gates to around 7,500. But it also plans to link quantum cores together, with the promise of up to 1,092 qubits via seven linked computers.

At the same time, IBM has released its Qiskit Code Assistant – powered by LLMs running on its watsonx platform, naturally – to help its partners write code that can run on forthcoming quantum computers. After all, what good is hardware without software?

BELOW Mark Lantz holding up a modern tape drive his team helped to develop

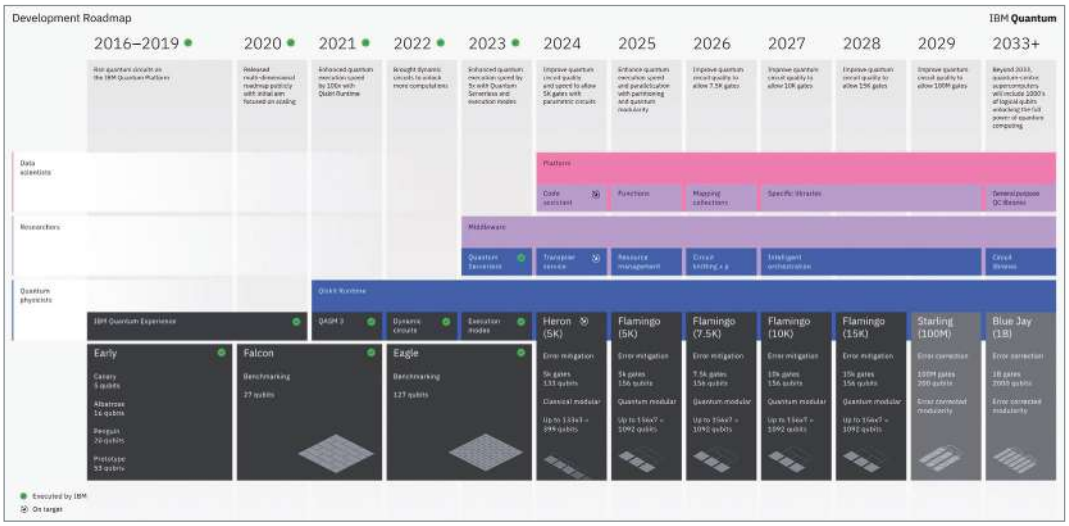
Tape storage is on the comeback trail

As part of our tour of the labs, we popped in to see Mark Lantz, a research scientist who manages tape research for IBM. "A lot of people are kind of surprised that IBM still sells tape products, let alone does advanced research on the topic," he said, adding that not only has it always been important in data centres but that we are in the middle of a "renaissance" for the technology.

That's because hard disks and SSDs can't keep up with the current data explosion. Hard disks are now approaching their maximum possible areal density, so data centres – particularly "hyperscalers" such as Amazon and Microsoft – need a new way to keep up. Tape storage is the answer, and its advantages aren't merely to do with scale and price.

Compared to a "27-petabyte hard disk solution, the tape solution has 96% less CO_2 emissions over a ten-year lifetime," explained Lantz. What's more, tape "has a built-in physical air gap [because] the cartridge isn't mounted in a drive. You can't modify the data. That gives you an extra layer of security."

The challenge for Lantz's team is to make tape data storage easy to use – he says tape specialists are no longer required with IBM's latest products – and to increase tapes' areal density. "Today, our high-capacity enterprise product operates with a 50 times lower areal density [than hard disks]," said Lantz. "So from this fundamental physics point of view, we have lots of room to keep scaling the technology... until we will get to the same areal density where HDD is."



BELOW IBM has committed to a quantum roadmap up to 2029

The A-List

The best products on the market, as picked by our editors

PC PRO A-LIST

PREMIUM LAPTOPS

Apple MacBook Pro M4

M4 beast from £1,599

from apple.com/uk

This M4 update to the already brilliant MacBook Pro line is an easy recommendation, so the big question becomes do you choose the 14in version from £1,599 or 16in from £2,499? And then how much do you upgrade, as Apple isn't afraid of high prices. But whatever you choose should last for years, and look great while it's doing it.
REVIEW Issue 364, p50

Apple Mac Book Air13in (M3)

Both the 13in and 15in MacBook Airs impress for speed, styling and battery life, but the 1.2kg 13in Air wins out of the two for its sheer portability. **From £1,299 from apple.com**
REVIEW Issue 356, p54

Asus Zenbook S 14 OLED

Asus pairs a Core Ultra 9 288V with a 72Wh battery to produce a laptop that lasts almost 20 hours on a charge. What's more, this 1.2kg machine looks (and feels) the business. **From £1,750 from scan.co.uk**
REVIEW Issue 362, p46

Asus ProArt PX13

With AMD's new Ryzen AI 9 HX 370 inside, this 1.4kg compact powerhouse offers incredible amounts of power. Add a fantastic OLED screen and RTX 4070 graphics and it's a winner. **From £2,000 from uk.store.asus.com**
REVIEW Issue 361, p50

BUSINESS LAPTOPS

Lenovo ThinkPad T14s Gen 6 (Snapdragon)

Copilot+ PC for £1,500 exc VAT

from lenovo.com

It's perhaps a controversial choice – and we wouldn't roll this out en masse – but if you're buying for executives or CTOs this cutting-edge Copilot+ PC, complete with a Qualcomm Snapdragon Arm processor, is a superb choice. Not only is it good value, it's light, it's fast and its all-day battery life is genuinely 24 hours.
REVIEW Issue 360, p56

NEW ENTRY

Lenovo ThinkPad X1 Carbon Gen 12

The X1 Carbon range has stepped up a gear thanks to Intel's Core Ultra chips, and Lenovo matches it with the stunning build quality and keyboard you'd expect. **From £1,375 from lenovo.com**
REVIEW Issue 358, p58

Dell Latitude 9450 2-in-1

This 14in convertible, based around Core Ultra CPUs, lacks for nothing, whether that's speed, battery life (around 16 hours), build quality or flexibility. **From £1,560 exc VAT from dell.co.uk**
REVIEW Issue 361, p63

HP OmniBook Ultra Flip

A top-quality 2-in-1 with a terrific 14in OLED panel, great build quality and superb battery life thanks to Intel's latest generation Core Ultra 7 processors. **From £1,699 from hp.com**
REVIEW Issue 365, p46

COPILOT+ PCs

Lenovo Yoga Slim 7x (Gen 9)

AI on demand, £1,350

from lenovo.com

You won't find a better-value laptop, never mind one that meets the Copilot+ PC criteria. With a Snapdragon X1E-78-100 inside it isn't the fastest in benchmarks, but it's incredibly nippy in practice, the battery lasts over 16 hours and the 14.5in OLED screen is top quality.
REVIEW Issue 361, p57

Samsung Galaxy Book4 Edge

A classy 16in laptop that weighs 1.6kg, uses the fastest Snapdragon Elite X chip and delivers a solid 12 hours of battery life. **512GB, £1,499 from samsung.com**
REVIEW Issue 360, p53

Microsoft Surface Laptop, 7th Edition

The poster child for Copilot+ PCs offers quality, great looks and staggering battery life. **From £1,049 from microsoft.com**
REVIEW Issue 360, p50

Asus Zenbook S 15 OLED

With a price drop to £1,200 this 15.6in laptop becomes a viable competitor to the Yoga Slim 7x if you need a bigger screen. **£1,200 from uk.store.asus.com**
REVIEW Issue 359, p52

EVERYDAY LAPTOPS

Acer Aspire 14 A14-51GM

Compact power for £850

from acer.com

Want gaming power? Buy the version with RTX 2050 graphics for £850 (part code NX.KSVEK.005). Just care about value? Get a Core 5 processor and integrated graphics for £600 (part code NX.KRWEK.00B). Whichever you choose, it's a staggering laptop for the price.
REVIEW Issue 359, p82

Asus Zenbook 14 OLED (UX3405)

If you can stretch past £1,000, this is a top-quality Core Ultra laptop with a superb 120Hz screen and great battery life. **From £1,099 from uk.store.asus.com**
REVIEW Issue 359, p58

Framework Laptop 13 (DIY Edition)

With a competitive price, modular approach and easy-to-repair ethos, you can pick and mix your perfect 13in laptop. **From £779 from frame.work**
REVIEW Issue 360, p58

Huawei MateBook D16

It's big and certainly not bashful, packing an Intel Core i9 chip and a high-quality 16in panel – and surprisingly good battery life, too. **£1,000 from huawei.com**
REVIEW Issue 359, p87

CHROMEBOOKS

Samsung Galaxy Chromebook Plus (2024)

Core 5 power for £749

from samsung.com

The first truly desirable Chromebook since the Pixelbook, this is a top-quality laptop from the all-metal chassis to the 15.6in Full HD OLED screen. And thanks to Intel's Core 5 120U processor, it's fast enough to last for years.
REVIEW **Issue 364, p65**

Acer Chromebook Plus 515

This Chromebook Plus laptop is all about value. With strong speeds thanks to Intel's Core i5-1235U processor, and a good-quality 15.6in panel with a 1,920 x 1,080 resolution, Asus' Chromebook Plus 515 is ideal for families, students and business users, providing mobility isn't your main priority as it isn't particularly light at 1.7kg. **£429 from currys.co.uk**
REVIEW **Issue 356, p82**

Acer Chromebook Spin 714

If you're looking for a convertible, this is the best choice around. Others may beat the 12th gen Intel Core i5 we tested for performance, but for features, design and bang for buck you won't find any laptop that can match this 2-in-1 for the money. **£799 from currys.co.uk**
REVIEW **Issue 356, p83**

MINI PCs

Apple Mac mini M4

Little monster from £599

from apple.com/uk

This is a big and timely update for the Mac mini, with a much smaller (and squarer) design that's easy to tuck behind a screen. But what lifts it above the pack is the astonishing power of the M4 and M4 Pro chips, with barely any cooling required. As ever with Apple the upgrade costs are high, but at least its starting price is reasonable.
REVIEW **Issue 364, p44**

Geekom A8 Mini PC

Geekom makes brilliant use of AMD's Ryzen 9 8945HS in this powerful mini PC, which occupies little more desktop space than a drinks coaster. And it still packs every port most people need, plus Wi-Fi 6E. If you don't need this much power (or 32GB of RAM and a 2TB SSD) the Ryzen 7 version is £719. **Ryzen 9, £899 from geekom.co.uk**
REVIEW **Issue 359, p62**

Minisforum Venus UM790 Pro

Ignore its basic looks, for this compact system packs in a fast AMD Ryzen 9 7940HS processor, 32GB of DDR5-5600 RAM and 1TB SSD along with a generous selection of ports, including two USB-C 4 connectors. And the price is super-aggressive. **£549 from store.minisforum.uk**
REVIEW **Issue 363, p91**

ENTHUSIAST PCs

NEW ENTRY

Wired2Fire HAL 9000 Compact PC

Mini powerhouse for £1,900

from wired2fire.co.uk

Wired2Fire proves there's no need to go big for top-level performance, squeezing a Ryzen 7 7900X and RTX 4070 Ti into a Cooler Master chassis measuring 185 x 295 x 377mm (WDH).
REVIEW **Issue 365, p59**

CyberPowerPC Infinity X145 Elite

Designed to deliver the maximum possible gaming power for £999, this Core i5-14400F system – with 32GB of DDR5 RAM and GeForce RTX 4060 graphics – is a great machine now with potential for more later. **£999 from tinyurl.com/360cyber**
REVIEW **Issue 360, p61**

NEW ENTRY

PCSpecialist Nebula Goliath

The best possible debut for Intel's Core Ultra 285K processor, with PCSpecialist teaming it up with an RTX 4080 Super to provide a versatile system for gamers and creatives alike. **£2,399 from pcspecialist.co.uk/configurereview/629**
REVIEW **Issue 365, p56**

ALL-IN-ONE PCs

HP Envy 34 All-in-One

£2,099 widescreen wonder

from hp.com

Built around a high-quality 34in widescreen – which is perfect for viewing two windows side by side thanks to its 21:9 aspect ratio – this also comes with Nvidia RTX 3060 graphics. We're big fans of the magnetic 16-megapixel camera, too.
REVIEW **Issue 335, p46**

Dell Inspiron 24 All-in-One

Despite being built to hit a price point, the Inspiron 24 All-in-One manages to look classy, include a good-quality, 1,920 x 1,080 24in panel and have enough power to breeze through a typical day's tasks. It even packs mod cons such as a 720p webcam. Superb value for money. **From £599 from dell.co.uk**
REVIEW **Issue 350, p47**

Apple iMac M4

Anyone hoping for a 27in iMac will be disappointed, but everyone else should be delighted by this M4-powered all-in-one with its 24in 4,480 x 2,520 IPS panel. It's fast inside and out, too, with Thunderbolt 4 and Wi-Fi 6E on offer. **From £1,299 from apple.com/uk**
REVIEW **Issue 364, p48**

CREATIVE WORKSTATIONS

Armari Magnetar M64T7-AW1650G4

Threadripping power for £8,329 exc VAT

from armari.com

AMD's Ryzen Threadripper 7980X is the star of this particular show, dominating our benchmarks with the help of 128GB of RAM, two 2TB Crucial PCI-E 5 drives in RAID0 configuration and AMD's Radeon Pro W7800 professional GPU. And it's all wrapped up in a custom Armari case with liquid cooling.
REVIEW **Issue 361, p92**

PCSpecialist Quantum Goliath R

Extracting maximum power from its budget by opting for consumer components with professional levels of power, this well-thought-out workstation couples Intel's Core i9-14900KS with RTX 4090 graphics to tremendous effect. **£3,750 exc VAT from pcspecialist.co.uk/reviews**
REVIEW **Issue 361, p89**

Scan 3XS GWP A1-TR64

A more balanced offering than Armari's Magnetar, Scan mixes a Threadripper 7970X with Nvidia RTX 5000 graphics – and a stunning supporting cast of components with an equally stunning case. Perfect for real-time viewsets and GPU accelerated computation. **£7,917 exc VAT from scan.co.uk**
REVIEW **Issue 361, p94**

TABLETS

Apple iPad Air (M2)

M2 power from £599

from apple.com

We love the new iPad Pro, but for most people the M2 iPad Air is not only far better value but also all the tablet they'll need. It supports the Magic Keyboard and Pencil Pro, plus it's now available in both 11in and 13in sizes.
REVIEW **Issue 358, p50**

Apple iPad Pro (M4)

The best tablet in the world becomes even better thanks to Apple's stunning M4 chip, a gorgeous OLED screen and the must-have accessory: the all-new Pencil Pro. But it comes with an obvious downside of cost, with the cheapest 13in incarnation costing £1,299. **From £999 (11in, 256GB) from apple.com**
REVIEW **Issue 358, p48**

OnePlus Pad 2

Last year the OnePlus Pad took its place alongside Apple's iPads on the A List – and this year it's done it again, with superb battery life of over 18 hours, a gorgeous design and great power making this new version an even better proposition. All for a price that's exactly right. **£449 from oneplus.com/uk**
REVIEW **Issue 364, p86**

EVERYDAY PHONES

Motorola Moto G54 5G

Great looker for £180

from johnlewis.com

The 6.5in 120Hz IPS display is the G54's standout feature, but it improves on the previous generation in numerous ways while being even cheaper. It's faster, looks better, takes great photos and battery life is strong. You won't find better for less than £200.
REVIEW **Issue 355, p77**

Google Pixel 8a

We're fans of the Pixel 8 but you can save £200 and buy the 8a without missing out on any key features, including its advanced AI skills thanks to the same Tensor G3 chip inside. It's only when you zoom into snaps that you spot the camera quality difference. **128GB, £499 from store.google.com**
REVIEW **Issue 358, p74**

Samsung Galaxy A55

Not the fastest phone on the market, but in return you get a high-quality 6.6in OLED display, excellent battery life and a trio of strong cameras. And you also get four years of feature updates. With a price that significantly undercuts the Pixel 8a, it's great value, too. **128GB, £364 from johnlewis.com**
REVIEW **Issue 358, p77**

PREMIUM PHONES

Apple iPhone 16 Pro

Class and quality from £999

from apple.com/uk

Even without Apple Intelligence, the introduction of a 5x optical zoom, classy 6.3in OLED panel and Apple's ludicrously fast A18 Pro chipset make this the best update to an iPhone Pro for years. The improved battery life is merely the cherry on top.
REVIEW **Issue 363, p70**

Honor Magic V3

With the Magic V3, not only does Honor make foldable phones as slim as flagship phones but also as affordable – so long as the £300 discount voucher still applies, as shown in the price here. What's more, the cameras and both OLED panels are superb. **£1,400 after discount from honor.com**
REVIEW **Issue 362, p62**

Motorola Razr 50 Ultra

Not merely a huge upgrade over last year's Razr 40 Ultra, this new model also leapfrogs over Samsung's new Flip6 to become our flip phone of choice. That's thanks to its great battery life, superb screens (particularly on the outside) and a camera that's a joy to use. **£1,000 from motorola.co.uk**
REVIEW **Issue 360, p68**

EVERYDAY MONITORS

Iiyama ProLite XUB3293UHSN-B5

32in 4K bargain, £429

from currys.co.uk

The fact that this 31.5in IPS monitor could compete so well against Eizo's alternative (*see below*) says it all. Great colour coverage in sRGB and DCI-P3, USB-C and RJ45 inputs, plus solid build quality add up to a bargain.
REVIEW **Issue 357, p88**

AOC Q27B3CF2

AOC's relentless focus on value delivers a 27in 1440p screen with a high-quality IPS panel that costs £200 including VAT – and also packs in a USB-C port. Those are almost the only features you get, and the OSD is awful, but at this price we're not complaining. **£200 from amazon.co.uk**
REVIEW **Issue 360, p77**

Acer Verso B277 Ebmiprzxv

This is a basic but high-quality monitor, delivering colourful images across its 27in Full HD diagonal. You don't get USB-C docking, but it includes VGA, HDMI and DisplayPort inputs, plus a two-port USB hub. **£149 from tinyurl.com/357acer277**
REVIEW **Issue 357, p84**

PROFESSIONAL MONITORS

Eizo FlexScan EV3240X

Stunning 4K quality, £1,206

exc VAT from photospecialist.co.uk

With images that whack you between the eyes as soon as you lift it, fully assembled, from its box, this 32in 4K monitor is our top choice pick for anyone willing to make such a hefty long-term investment.
REVIEW **Issue 357, p91**

Eizo ColorEdge CG2700X

A brilliant choice for professional designers, whether working solo or in teams, thanks to its dedication to providing accurate colours across potentially years of life. It's also bang up to date for connectivity, with USB-C and RJ45 making it easy to manage, too. **£2,149 exc VAT from wexphotovideo.com**
REVIEW **Issue 357, p90**

BenQ PD2706U

If you can't stretch to Eizo budget levels then this 4K 27in screen is definitely worth investigating. It has several features aimed at professionals, including a Hotkey Puck to switch between profiles, plus great coverage of the sRGB and DCI-P3 gamuts. **£333 exc VAT from scan.co.uk**
REVIEW **Issue 357, p86**

WEBCAMS

Logitech MX Brio 705 for Business

Consistent brilliance for £219

from logitech.com

Consistent image quality in all lighting conditions coupled with top build quality and nifty features – such as a presenting mode for items on your desk – make this a fantastic all-round choice.
REVIEW Issue 356, p68

Logitech Brio 105 for Business

While you can buy 1080p webcams for a third of the Brio 105's price, they won't hold a candle to the Logitech webcam's quality – especially in low-light conditions, such as one candle. It's also easy to manage, for businesses and individuals.
£45 from logitech.com
REVIEW Issue 360, p77

Obsbot Tiny 2

This portable 4K webcam delivers for quality, design and sharpness, and it comes with a shedload of advanced features, including dynamic zoom and subject tracking. The only real downside is that it has a price that reflects its premium ambitions.
£329 from amazon.co.uk
REVIEW Issue 352, p75

HOME OFFICE PRINTERS

NEW ENTRY

HP OfficeJet Pro 9135e

Do-it-all inkjet for £193

from printerbase.co.uk

This versatile inkjet all-in-one – which includes a 35-page ADF – pumps out high-quality prints at laser-rivalling speeds. Likewise scans and copies. Print costs are reasonable, too.
REVIEW Issue 365, p85

NEW ENTRY

Epson EcoTank ET-2865

As usual with ink tank printers, you don't get many frills with the Epson EcoTank ET-2865 (so no ADF or screen). What you do get is incredibly low running costs of 0.5p for colour and 0.2p for mono, plus high-quality prints and scans.
£233 from uk.insight.com
REVIEW Issue 365, p84

NEW ENTRY

Canon i-Sensys LBP243dw

Everything you could want from a mono laser printer – it doesn't come with a scanner – the LBP243dw produces excellent results at speed. You also get Wi-Fi and wired networking. **£186 from printerbase.co.uk**
REVIEW Issue 365, p88

WORKGROUP PRINTERS

Canon Maxify GX6550

Ink tank all-in-one for £392 exc VAT

from canon.co.uk

Designed to fit in tight spaces, this all-in-one includes a highly effective ADF and backs it up with high-quality prints at 24ipm in our tests. Running costs are superb, too.
REVIEW Issue 350, p58

Brother HL-L9430CDN

This laser printer (not an all-in-one, so there's no scanning or copying functionality) is a great choice for a busy office, producing sharp black text and making a good job of colour graphics as well. All while doing so quickly with a competitive price per page. **£415 exc VAT from printerland.co.uk**
REVIEW Issue 353, p84

Xerox B315DN

A fine alternative to the Brother and Canon, this mono laser multifunction printer produces superb results at great speed – 27.5 pages per minute in our 50-page test, which includes the spool time. It's similarly quick for scans, with a dual-CIS ADF to speed up double-sided copies. **£238 exc VAT from printerbase.co.uk**
REVIEW Issue 341, p87

WIRELESS ROUTERS

Netgear Nighthawk RAXE300

Fast Wi-Fi 6E router, £350

from amazon.co.uk

The RAXE500 is faster than the RAXE300, but in practice we doubt you would notice – this tri-band router still delivered speeds between 50MB/sec and 150MB/sec in our tests. And it's packed with features, too. At £150 cheaper than its bigger brother, we think it hits the Wi-Fi 6E sweet spot.
REVIEW Issue 341, p68

Netgear Nighthawk RS700S

Make no mistake – you won't get stunning speeds out of this Wi-Fi 7 router today. But if you must buy a router now and want future-proofing, this is a solid choice. But honestly, we would recommend that you wait.
£800 from netgear.com
REVIEW Issue 353, p76

Asus RT-AX59U

You can buy cheaper Wi-Fi 6 routers – such as the D-Link Eagle Pro AI R15 for £55 – but Asus' well-priced offering delivers strong performance along with lots of control and exceptional VPN support. **£125 from uk.store.asus.com**
REVIEW Issue 350, p57

MESH WI-FI

TP-Link Deco XE200

Clever Wi-Fi 6E for £400

from amazon.co.uk

There are cheaper Wi-Fi 6E meshes, but the XE200 wins for its superb download speeds, excellent coverage and the fact that older clients reap benefits of 6E, not just new ones. And a two-pack (code B0BKTDPWC8) should be enough for most premises.
REVIEW Issue 349, p65

Netgear Orbi 770

If you're eager to upgrade to Wi-Fi 7 then the Orbi 770 is the best mesh option yet. Its speed and range are both excellent, with a twin-pack covering 420m² (says Netgear), and the wired connectivity superb: four 2.5GbE connectors on the router unit, two 2.5GbE ports on the satellites. But it ain't cheap. **2-pack, £600 from amazon.co.uk**
REVIEW Issue 364, p70

Linksys Velop Pro 6E

Ironically, this Wi-Fi 6E router will get the most out of your non-Wi-Fi 6 devices thanks to its use of the 6GHz network for station-to-station traffic. And you only need two units for rock solid performance across a three-bedroom house. **2-pack, £380 from amazon.co.uk**
REVIEW Issue 350, p54

BUSINESS WI-FI

NEW ENTRY

NEW ENTRY

Ubiquiti UniFi U7 Pro Max

Wi-Fi 7 AP, £214 exc VAT

from broadbandbuyer.com

A great choice for SMBs seeking a powerful and affordable upgrade to Wi-Fi 7. You'll need a UniFi controller to complete the wireless picture, but this investment will be paid back handsomely as they offer the best cloud management services around.

REVIEW Issue 365, p100

TP-Link Omada EAP783

This slim-line discus has a mighty BE19000 rating and will appeal to businesses looking to make an early transition to Wi-Fi 7. It delivers superb performance and is MLO-ready, while TP-Link's Omada cloud platform offers great remote management services. **£520 exc VAT from senetic.co.uk**

REVIEW Issue 360, p103

EnGenius ECW536

The ECW536 delivers on all fronts: this mighty BE19000-rated Wi-Fi 7 AP is impressively fast and incredibly good value. It can only be cloud-managed, but the EnGenius portal is easy to use and delivers a wealth of wireless management and monitoring services. **£386 exc VAT from solwise.co.uk**

REVIEW Issue 365, p98

NAS SERVERS

Synology DiskStation DS1823xs+

10GbE NAS, £1,413 exc VAT

from broadbandbuyer.com

This powerful eight-bay NAS is a great choice for SMBs that want plenty of capacity, features and performance at a reasonable price. The new DSM 7.2 software has security high on its agenda, and the icing on the cake is Synology's generous five-year warranty.

REVIEW Issue 346, p101

Qnap TS-h987XU-RP

The TS-h987XU-RP is a ready-made hybrid storage solution for SMBs. This rack-friendly package offers a great specification for the price, and Qnap's QuTS hero software scores highly for its wealth of data-protection features and business apps. **Diskless, £3,292 exc VAT from broadbandbuyer.com**

REVIEW Issue 344, p96

Synology DiskStation DS1522+

Small businesses that want a high-capacity desktop NAS at a good price will find Synology's DS1522+ a great choice. Performance over 10GbE is impeccable and the DSM software offers a fantastic range of storage features. **5-bay NAS, diskless £586 exc VAT from broadbandbuyer.com**

REVIEW Issue 344, p98

VIDEOCONFERENCING

Biamp Parlé VBC 2800

Go big for £2,918 exc VAT (MSRP)

from midwich.com

We thought the VBC 2500 was a great VC room bar, and the new VBC 2800 delivers Biamp's undeniable expertise to larger meeting rooms. Video and audio quality are outstanding, speaker framing is super fast and the smart combination of dual camera lenses makes sure everyone is in the big picture.

REVIEW Issue 364, p98

Owl Labs Medium Room Solution

The Owl 4+ and Owl Bar partnership offers smart tracking and dynamic split-screen views to ensure everyone is in the picture, while the Whiteboard Owl adds extra professionalism to presentations and training sessions. **Owl 4+, Owl Bar, TV mount, £2,999 exc VAT from owllabs.co.uk**

REVIEW Issue 364, p100

Ricoh Meeting 360

Ricoh's Meeting 360 is up against stiff competition in the panoramic meeting hub market but stands out for its excellent build quality and generous three-year warranty. It's easy to use and delivers good video and audio quality, while the smart app allows you to create a view for every occasion. **£744 exc VAT from amazon.co.uk**

REVIEW Issue 364, p101

SCANNERS

NEW ENTRY

Xerox N60w Pro Scanner

Speed demon, £766 exc VAT

from tradescanners.com

The N60w Pro offers tremendous value and versatility. It delivered up to 67ppm in our tests with great output quality, offers a plethora of connection options and makes walk-up scanning a breeze.

REVIEW Issue 358, p101

Brother ADS-4500W

Ideal for small businesses, the ADS-4500W offers a fine set of walk-up scan features and its output quality is beyond reproach, while Brother's Print&Scan app delivers great scan workflow management options. **£295 exc VAT from printerbase.co.uk**

REVIEW Issue 358, p98

Epson WorkForce DS-800WN

A flexible desktop scanner with 50ppm pace and lots of connection options. Epson's software provides great scan management features, and support for Epson's Open Platform is a boon for document management. **£656 exc VAT from ballicom.co.uk**

REVIEW Issue 365, p103

SERVERS

Dell EMC PowerEdge T350

Xeon E-2300 power, from £1,399 exc VAT

from dell.com

Perfect for SMBs and branch offices looking for an affordable and powerful single-socket tower server. Along with support for Xeon E-2300 CPUs and lots of memory, it has a high storage capacity, plenty of expansion space and is sturdily built.

REVIEW Issue 335, p98

Dell EMC PowerEdge R250

With prices starting at around £850 exc VAT for a Pentium Gold CPU, and the option of Xeon E-2300 series chips from £1,461 exc VAT, this is a slim, rack-mounted alternative to the more high-powered T350 that's ideal for SMBs. **From £845 exc VAT from dell.com**

REVIEW Issue 332, p98

Broadberry CyberServe Xeon E-RS100-E10

This represents a powerful hardware package at a price that will please small businesses. We love its low-profile chassis and the fine selection of remote-management tools. It's a great alternative to the Dell EMC servers also listed here. **£983 exc VAT from broadberry.co.uk**

REVIEW Issue 318, p96

SECURITY SOFTWARE

Avast Ultimate

Buy from retail and this is a bargain, with a solid VPN, anti-tracking software and handy detection fees on top of excellent protection. **10 devices, 2yrs, £30 from store.pcpro.co.uk**
REVIEW **Issue 355, p84**

G Data Total Protection

G Data provides straightforward, effective and inexpensive protection against malware and other threats to your system, making it a favourite despite its quirks. **5 devices, $82 from gdatasoftware.co.uk**
REVIEW **Issue 355, p87**

Avast One Essential

Avast One Essential has the same malware-detection engine as our top choice, but for free. It even includes 5GB of VPN services per month and a few system optimisation tools. **Free from avast.com**
REVIEW **Issue 355, p89**

VPNs

Surfshark

Reliably fast and goes out of its way to ensure that international streaming services work. Surfshark has a credible track record for privacy, too. **£55 for 27 months from surfshark.com**
REVIEW **Issue 360, p87**

NordVPN

One of the best all-purpose consumer VPN services around, and the paid-for version is packed with features – from anti-malware tools to a rather clever mesh file-transfer system. **£94 for 27 months from nordvpn.com**
REVIEW **Issue 360, p85**

Proton VPN

A great VPN in its own right, but also the best free VPN service as you get unlimited data. Instead, Proton restricts which endpoints you can access to only three countries: the USA, the Netherlands and Japan. **Free from protonvpn.com**
REVIEW **Issue 360, p86**

PASSWORD MANAGERS

NordPass

This hassle-free option is a great choice for both personal and business use, with a competitive price matched with all the features most people need. **£1.89 per month from nordpass.com**
REVIEW **Issue 350, p70**

Bitwarden

Free for individual use and open source, the only important thing Bitwarden lacks is phone support: it works with virtually every device and browser, and the paid option is well worth £10 per year. **Free from bitwarden.com**
REVIEW **Issue 350, p71**

Keeper

A great choice for businesses thanks to its focus on security and a zero-knowledge policy, and if you need more options then Keeper has them. **Business edition, from £2 per user per month from keepersecurity.com**
REVIEW **Issue 350, p72**

ON-PREMISES BACKUP

Nakivo Backup & Replication 10.11.2

Perfect for SMBs that want the freedom to choose their host system. It supports an incredible range of hardware platforms and OSes and is packed with data protection features. **Enterprise, 10 servers, perpetual licence, £1,118 exc VAT from nakivo.com**
REVIEW **Issue 362, p100**

Veritas Backup Exec 23

Backup Exec 23 is easy to manage, provides valuable ransomware protection and the subscriptions are great value. **Simple Core Pack, 5 instances, £498 exc VAT per year from uk.insight.com**
REVIEW **Issue 362, p101**

CLOUD BACKUP

IDrive Business

A top cloud backup choice for SMBs that want to protect on-premises systems and remote workers. Platform and business app support is outstanding, it's easy to use and the simple capacity-based subscriptions are incredibly good value. **5TB, £838 exc VAT per year from idrive.com**
REVIEW **Issue 359, p101**

Acronis Cyber Protect 16 Advanced

Flexible subscriptions keep costs under control, the EDR service stays one step ahead of cybercriminals and it's easy to manage, too. **From £95 exc VAT per year from acronis.com**
REVIEW **Issue 359, p98**

VOIP SERVICES

3CX Phone System V20

Our top choice for businesses that want to manage their own VoIP system. It can be hosted in the cloud or on-premises, and has lots of new features. **Small Business, 10 users, £175 exc VAT per year from 3cx.com**
REVIEW **Issue 357, p98**

TelephoneSystems.Cloud

A great choice for businesses that know what they want from cloud-hosted VoIP services, offering a wealth of features at a good price. **From £11 exc VAT per user per month from telephonesystems.cloud**
REVIEW **Issue 357, p100**

ENDPOINT PROTECTION

WithSecure Elements Endpoint Security

A comprehensive set of protection measures for a great price, easily managed from a cloud portal. It supports a wide range of devices and the Luminen tool delivers AI-powered reporting services that present detailed summaries of events with a click. **100-499 devices, £37 exc VAT each per year from withsecure.com**
REVIEW **Issue 363, p101**

Sophos Intercept X Advanced

An unbeatable range of tough security measures. Deployment is a breeze, and a multitude of security policies make it highly flexible. **100-199 users, £48 exc VAT each per year from enterpriseav.co.uk**
REVIEW **Issue 363, p98**

REMOTE SUPPORT

NetSupport Manager 14.1

Sets the standard for on-premises hosted support for local and remote workers. It delivers a remarkable range of features and its one-time cost per seat will appeal to businesses concerned about subscription fees. **1-500 systems, perpetual licence, £10 each exc VAT from netsupportmanager.com**
REVIEW **Issue 361, p100**

ISL Online Standard

Perfect for SMBs wanting cloud-based support. Features and access security are excellent, as are its flexible licensing plans. **Standard Cloud/One user, £287 exc VAT per year from islonline.com**
REVIEW **Issue 361, p99**

SECURITY APPLIANCES

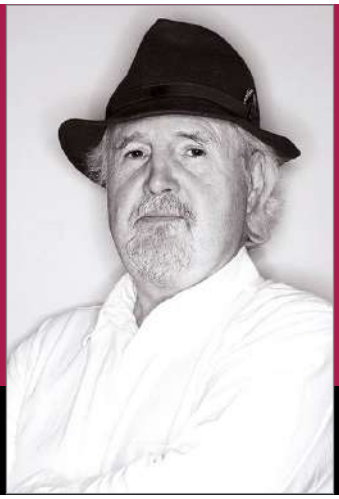
Firewalla Gold Pro

A great choice for small businesses that delivers a wide range of security features at a tempting price. Our 10GbE tests show it can easily cope with high demand, and you don't have to worry about subscriptions either, as the price includes all security services and lifetime updates. **$899 (£676) from firewalla.com**
REVIEW **Issue 364, p103**

DrayTek Vigor 2927Lax-5G

This affordable security router offers always-on internet access thanks to an unbeatable set of WAN redundancy features and also offers built-in Wi-Fi 6 services. **£667 exc VAT from broadbandbuyer.com**
REVIEW **Issue 360, p98**

Is that the final Trump of doom I hear?



PC Pro editorial fellow Dick Pountain is busy gathering followers on BlueSky (@dick-pountain) as an act of Xtermination

What could possibly be convincing the once liberal owners of big tech, and now multi-billionaires, to switch their allegiance to the new president?

I've been writing this column for 30 years, during most of which I've kept my political opinions out of it, apart from the occasional nod and wink about my lack of faith in free-market dogmas. However, there are, very occasionally, historic events of such importance that to avoid mentioning them would be a sign of cowardice. The last such event was the destruction of the World Trade Center on 11 September 2001, and I did permit myself a column on that. To me the re-election of Donald Trump on 5 November 2024 is another such event.

I have long been commenting on the rising power of Silicon Valley moguls – corporations such as Microsoft, Apple, Amazon, Facebook, eBay, HP, Twitter and more – who built the industry whose products we document in this magazine. And during those 30 years I have written under an unspoken assumption that these moguls, having emerged from the post-1960s counterculture, were fundamentally inclined toward "liberal" (in the American sense) values. The two Steves, Jobs and Wozniak, were once "blue box" phone phreaks; Google was started by two Stanford students in a friend's garage under the motto "Don't Be Evil". And in the interest of full disclosure, *PC Pro* itself was created by a company founded by Felix Dennis, once editor of *Oz* magazine, on which I too worked.

In order to remain neutral, over the past couple of years I've refrained from expressing alarm as it's become clearer that my assumption was being overturned. It started to look really shaky when Elon Musk bought Twitter and proceeded to corrupt it from a vital news resource for journalists of all persuasions into X, a conduit for previously banned hate speech and pro-Trump propaganda. Then a week or so before the November election Musk openly came out for Donald Trump and appeared prancing on platforms with him. Meanwhile, Jeff Bezos, owner of the *Washington Post* as well as Amazon, forbade its editors to endorse any candidate, while Mark Zuckerberg announced he'd made a "20-year mistake" and a "political miscalculation" (code for dumping the Dems).

> "It started to look shaky when Musk bought Twitter and started to corrupt it from a news resource"

What has induced such a handbrake turn in these billionaires' opinions? A stock price rally following Trump's victory increased their collective fortunes by $64 billion overnight, but that's merely chump change: Musk spent $250 million to finance Trump's election campaign, a sum he earns every 15 minutes. Trump is promising to oppose internet regulation and prosecute journalists who investigate or criticise too much, but I think even those aren't sufficient bait. These moguls already had everything except power to rule, which is now on offer.

The other promise Trump makes is to dump the Democrats' (already feeble) policies toward climate change mitigation, turning the USA away from the Paris Agreement and Net Zero. This very well suits a second generation of moguls – the AI barons. My own attitude to AI has changed somewhat over the past few years: I've been sceptical of earlier claims that silicon tech will soon produce intelligence equivalent to or greater than humans, a goal now renamed as AGI, but I'm enormously impressed by the strides made in language and perceptual processing (I did after all let ChatGPT write a guest column for me).

> "If Trump humours his new silicon buddies by employing their AI products to displace huge numbers of human jobs, he'll likely trigger social unrest"

Three AI problems are becoming visible. The first is that those who *really* know (as opposed to hyping a stock-price bubble) are as sceptical as I am about whether merely adding more GPU and training data will push GPTs into AGI: there are already signs of plateauing or even degeneration through data pollution. A second problem is the absurd, even obscene, amount of electrical power consumed by the huge processing arrays that support current generative AI models. Pronouncements about its future energy needs are beginning to sound frankly deranged – restart old nuclear power stations to marginally improve AI services which are, let's face it, really only souped-up search engines rather than solutions to any physical-world problems. Building a new clean energy infrastructure to mangle words and bitmaps rather than providing clean transport, heating and air conditioning is actually psychotic.

The third problem is that if Trump humours his new silicon buddies by employing their current, flawed, AI products to displace huge numbers of human jobs, he'll likely trigger an economic crisis that leads to social unrest or even breakdown. This magazine is called *PC Pro*, the first P standing for Personal. We grew out of a 1980s technical revolution that put computing power into the hands of individuals and decentralised power away from the mainframes of state bureaucracies. The ambitions of the AI brigade concentrate processing back into gargantuan data centres that threaten data democracy itself.

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Gap between tech promises and reality is too wide

Nicole Kobie is *PC Pro*'s Futures editor, and she'll never get over how terrible the internet has become. What a letdown.
@njkobie

Technology has been saving us time and supposedly making the world better for decades, so how come it takes so long to book a GP appointment?

Remember life before the internet? Looking something up meant dusting off an encyclopedia or heading to the library. Talking to friends required a phone or meeting them in person. Wild times.

The rise of the internet promised perfect information: we'd never be wrong again. We'd be flooded with facts, be it the name of a football player for a pub quiz, a politician's voting record or a restaurant's opening time.

All of that information is readily available. But instead of growing into well-educated, well-informed citizens, we're as stupid as ever – perhaps, given the rise of conspiracy theories, even stupider. The rise of misinformation and disinformation means the data available online can't be trusted, and we're far too set in our ways to seek out facts that disagree with us when there are so many available that fit our points of view.

That's just the information side of the internet. Digitalisation promised to open up access to everything, and if you look at banking then it has: not so long ago we needed to queue to get anything done beyond taking out cash at a machine. I remember having to wait half an hour in a branch to deposit a cheque. Now I just take a picture of it and the money appears in my account.

> "Instead of growing into well-educated, well-informed citizens, we're as stupid as ever – perhaps even stupider"

But it also means I'm now my own travel agent, my own banker and my own personal assistant – and as not everything is digital, this is a massive time waster. My GP technically offers appointments that are bookable online, but there's always just one, several weeks in the future at a very inconvenient time. Instead, it's a battle on the phone at 8am to get seen. The same goes for calls to government, my pension provider and any query that can't be answered by a chatbot.

Weren't digital services supposed to cut the costs of public services while improving access? And yet here we are, still hanging on the phone with not enough money in the budget. I can only assume those millions ended up with digital contractors supplying various technologies and services.

And don't get me started on the internet's promise of free and easy communication. When I moved to the UK 20 years ago, I racked up long-distance phone bills talking to friends and family for hours. Now, calling is free, but instead we send a few short messages back and forth and call that keeping in touch. (I know I could pick up the phone, but I'm as flawed and lazy as anyone.)

What happened? What is it about us humans that we manage to take these gifts of technology and turn them so sour? The very early days of the internet were fabulous. But it seems the more we could do online, and the more people got online, the worse it became.

I was thinking about this missed opportunity to benefit from the internet while reading a piece in *Time* magazine by Marc Benioff, founder and CEO of Salesforce – and also the owner of *Time*, in case you wonder why that piece (**tinyurl.com/365time**) sounds less like journalism and more like fan fiction.

Here's the gist: advances in AI promise, says Benioff, an unlimited age of plenty with little work, improving everything from customer service to healthcare. AI agents, he predicts, will open up access to the best of care virtually. Mate, we've heard that one before, and I still can't get an appointment at my local GP.

He adds: "All of this is a reminder that technology itself is neither good nor bad; what matters is how we use it."

True, but the problem is this: people are the worst. We were given perfect access to information, and we descended into conspiracy. We could have enabled true teleworking – remember when we used to call it that? – that enabled work-life balance, let parents return to work more easily, eased transport congestion and offered access to good work to anyone, regardless of disability or even geography. And yet, we're seeing demands to return to the office.

> "The very early days of the internet were fabulous. But it seems the more we could do online, and the more people got online, the worse it became"

I'm not saying AI can't deliver on its promises. But even if these tools pan out to be as powerful as Benioff et al claim, I'm not sure they or we will apply them intelligently. We have a terrible track record, after all.

Early evidence isn't looking good. Large language models are incredible prediction machines, yet every single time I try to type the word "and" on my iPhone keyboard, it replaces it with "Ave". Fix that, then we'll talk about the rest of the world.

If AI goes the way the internet did, I don't foresee an age of unlimited joy, money or other benefits. I expect yet another age of frustration and disappointment, just this time using much more expensive, dangerous and environmentally damaging tech. I hope this time they can prove me wrong, but I'm not holding my breath. We don't need technology to make everything better. We need to do the work – we're the problem, after all.

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How I miss the missing manuals

Forget wikis, YouTube videos and Q&As, application support was so much better in the days of printed manuals

Barry Collins wrote his dissertation on the Amstrad NC200, before having to convert the documents to ASCII format to print it off from a PC. That was fun. Email him at barry@mediabc.co.uk. @bazzacollins

In 1993, Amstrad launched the NC200 – a wonderful little laptop that I hoiked off to university with me. It looked like it could have been made by Fisher-Price: if you wanted to open the word processor you pressed the red button, for "diary" you pressed blue. In other words, it was almost insultingly simple to operate. And yet it came with a 460-page manual that was as chunky as the laptop itself.

The first 50-page section of that manual, according to the foreword, was written by none other than Alan Sugar. And even if – like me – you struggle to believe that Sugar sat there for hours pounding out an instruction manual, it's written in that gruff, no-nonsense style that at least sounds a bit like him. For example, the instructions for the delete keys (yes, really) tell you to press the button to make letters "disappear". "The Boffins say they were DELETED," (faux) Sugar adds. "Got it? Del is short for DELETE." Yeah, thanks for spelling that out, Al, it had been keeping me awake.

I take the mick, but that manual was brilliant. It's sitting in front of me, and I can see how well thumbed it was. It covered literally everything that primitive laptop could do in detail, with graphics and screenshots throughout. And remember this is 1993. I cannot even conceive how they got screenshots off the thing, let alone the difficulties of laying them out in a manual using the DTP software of the time. It is, in all sincerity, a hugely impressive piece of work. (You can see it for yourself by heading to **ncus.org.uk/m200.htm**.)

Of course, printed manuals have largely gone the way of dot-matrix printers and cans of Lilt. They're practically extinct. They've been replaced with "online guides", wikis or YouTube tutorials – which are often not a patch on a proper printed manual.

I've been building a new website with WordPress.com over the past couple of weeks, and even though WordPress has grown more user-friendly over the years, there have still been times when I've needed help in making a Query Loop behave or adjusting various settings. On numerous occasions I've found that WordPress' online help system has outdated information, where a feature or function has been updated and the instructions haven't been.

Worse, when I turned to the support team for help – the £250-per-year Business plan supposedly offers "priority 24/7 support from our expert team" – I was left waiting for hours before an AI bot sent me a boilerplate email that didn't answer my question. It was more than 12 hours later before a human actually helped me solve the issue.

It's a similar story with apps such as Photoshop and InDesign. Yes, Adobe has an online user guide and tutorials, but I often find they don't have the exact answer for what I'm trying to achieve. More often than not, I resort to third-party YouTube videos for the solution, but the quality of these videos is highly variable and often they're using a version of Photoshop that is two or three iterations out of date. Is it too much to ask for even a downloadable PDF manual for a product that costs hundreds of pounds per year? More than that Amstrad laptop did, in fact.

> "Is it too much to ask for even a downloadable PDF manual for a product that costs hundreds of pounds per year?"

It's a similar story with games. Video games used to be the apogee of manuals – those beautifully written guides with maps and game lore you used to pore over before sticking the disks in the Amiga, say. Now, at best, you can hope for an in-game tutorial (most of which suck) and an online wiki that has less craft than a wheelie bin.

> "At best, you can hope for an in-game tutorial (most of which suck) and an online wiki that has less craft than a wheelie bin"

I recently tried getting into Flight Simulator 2024, but the sheer number of controls you have to master makes you appreciate why it takes years of training to become a pilot. It's too much for the casual gamer. Unless you're prepared to devote hours to learning it all it's near impossible, at least for this 40-something with a memory weaker than Alan Sugar's punchlines. But if I had – or could order – printed control sheets reminding me what all those sodding buttons do, I might have half a chance of landing a Cessna without having to be cut out of the cockpit by the fire brigade.

Manuals aren't a completely lost cause. A few years ago, Serif produced a couple of wonderful guides for its Affinity Photo and Publisher apps. Proper, hard-bound, glorious-smelling glossy guides that walked you through how to use the software, with pull-out keyboard shortcut sheets to boot. They were magnificent, well worth the £20 or so asking price.

I'd happily pay for a printed Photoshop, WordPress or Flight Sim manual, if only the companies were prepared to cover their own products as comprehensively as Amstrad did all those years ago. Alan Sugar or AI? Give me the grizzly old sod any day.

barry@mediabc.co.uk

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Readers' comments

Your views and feedback from email and the web

Business class Wi-Fi

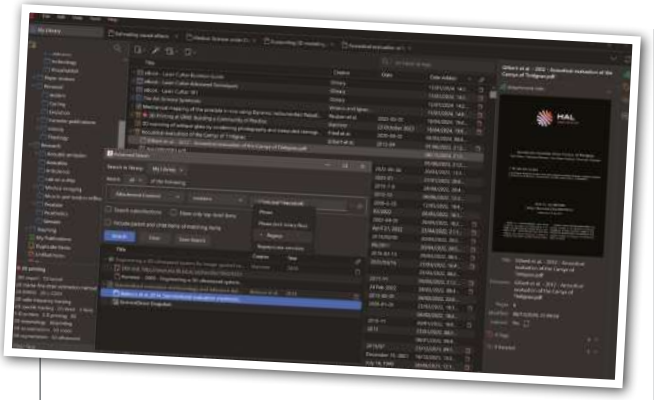
Thanks so much for the Upgrade to Business Class Wi-Fi article (*see issue 364, p40*). In 2024 I upgraded my own home/office network to a TP-Link business mesh system and don't regret it. There are two things to add to the article, though. First, many of the subscription features available on the Zyxel system Darien chose are included in the software of other routers, including my own, which is only about £20 or so more expensive. Second and most importantly, while guest networks allow you to isolate IoT, plus kids' and visitors' devices, to boost security, only a professional router will allow you to do the same with Ethernet, which is becoming more popular for devices including smart TVs used for streaming.

Mike Halsey

Associate editor Darien Graham-Smith replies: "Good point – no doubt I'll be discovering additional benefits of a pro-grade router for a long time to come. The only catch is that you need to be willing to delve into quite advanced settings, and to live with the possibility of temporarily stuffing up your home network while you're exploring what you can do – which I doubt my family will appreciate!"

PDF reference manager

Has Dick Pountain ("In praise of the mighty PDF", issue 364, p20) considered a reference manager to catalogue and search his PDF library? I've used Zotero (**zotero.org**) for years and it's a great tool for writers and academics who have lots of PDFs and other documents to manage.



ABOVE Dr Steven Hammer recommends Zotero as a tool for writers and academics

Zotero can use regular expressions for searching within attachments, too (see screenshot above). It also handles PDF viewing and annotation using its built-in viewer. You can make quick additions to your library from loads of different websites using the Zotero Connector browser plugin. Zotero is available for various devices, including Chromebooks.

Sadly, it doesn't read and critically review the articles for you. I'm still looking for a tool to do that...

Dr Steven Hammer

Editorial fellow Dick Pountain replies: "Thanks, Dr Hammer, for your tip-off about Zotero, which I didn't know about and which looks like exactly what I need. I'll certainly be trying it: I will wait for the Android version, which the website says is 'coming soon'."

Return of the Luddites

From the point the Luddites lost their argument (and some of them their lives) in 1811, our economic model had been based on the philosophy "if you don't move forwards you inevitably move backwards". The strategy has helped humankind in creating PCs and phones work in ways that we could barely imagine 20 years ago.

So it comes as no surprise that governments around the world are giving out licences for drone deliveries. In the rush to move the economy on, has anyone paused to think what the future holds? Not only do drones emit high-frequency sounds that are intensely annoying to the human ear but, whereas a delivery van will be heard up to around 100 metres, a drone flying at 1,000 feet might be audible over several square miles!

In this "brave new world" every city dweller will experience noise pollution akin to living near a major airport! That reminds me to send off that application form for membership of the Neo-Luddite society.

Nigel Osborn

Max not mini

The December 2024 issue asked whether we are tempted by mini PCs. I was, but no longer. It would replace one of my self-build computers that is a standby and used for online meetings. One Geekom and three Minisforum mini PCs later, they have been returned because of failures or not meeting the specification.

The Minisforum Venus UM790 Pro failed to switch on after being run for 90 minutes from new. I eventually rebooted it but it had self-encrypted with BitLocker. I'll admit that I've

Star letter

We hear you!

I was perusing my latest copy of *PC Pro*, December 2024, over breakfast and was enjoying the articles and advice given until I reached p68. I read the reviews from p68 all the way through to p76 and then re-read them again. Surely I had missed something of significant interest.

No matter how many times I read the reviews I couldn't find any reference to the telecommunication abilities of the various iPhones, Apple Watch or other phones. Surely, if you are going to "review" a phone you should be highlighting its abilities as a phone, not just a camera? I was looking for information such as "how long does the battery last on standby", "what are its abilities in connecting to networks", "how many contacts can it store", "does it have emergency services abilities" and so on.

Please, if you are going to review a smartphone, review all its abilities.

Edward Henry Holroyd

Editor-in-chief Tim Danton replies: A tricky one. A bunch of factors come into play here, including the role of software; for example, three of those four questions relate to the OS rather than the hardware, and we tend to focus on the hardware in our reviews unless there's something unique about the software package. We also try (and often fail) to avoid covering things that can be looked up online on the manufacturer's website; our reviews attempt to tell you what the product is like to use, which is why we'll concentrate on experiential things rather than raw numbers where possible. But I do realise that our reviews include a lot of numbers, too, as we try to obey the mantra "no opinion without fact". Hopefully that answers the question to some extent!

This month's star letter writer wins a Cherry KC 200 MX mechanical keyboard, worth £80, recipient of a five-star review and a *PC Pro* Recommended award. Email letters@pcpro.co.uk

been spoiled over the years with Asus' UEFI BIOS. So here I am, with a new self-build based on a ROG Strix Z790-H motherboard and Core i7-14700K CPU that work faultlessly.
John Knight

The Collins Replacement Cycle™

In response to Barry's column (*see issue 364, p22*), where he describes his CRC (Collins Replacement Cycle™) as being broken by the Apple M1, meaning his laptop will last longer than its planned three years, I certainly agree, but I would say it goes beyond Apple. My 2020 vintage LG Gram laptop is as fresh now as the day I bought it, and only partly due to the Format C: followed by a reinstall of Windows a few months back.

The real reason is fast SSDs, decent CPUs and an abundance of RAM. I remember the days of the Windows Task Manager showing maxed-out RAM and CPU, while the spinny disk struggled with the demands of the swap file, slowing everything to a crawl. But no more; the hardware is finally outpacing the software, so the focus became on making the hardware small, light, cool and efficient to preserve battery life and to make them 20% thinner than last year's model.

It makes you wonder where the hardware manufacturers will go next. What's that? NPUs, you say...
Alan Ingram

Rolling back the years

I received my January 2025 edition on 30 November 2024. Interestingly, the December 2024 edition states the January edition goes on sale on 5 December 2024. After I read it, this morning I couldn't find the magazine! I went around the house twice, before I eventually realised that the spine says "January 2024", and I had filed this with my back copies. And it's not even 1 April.
John Haigh

Editor-in-chief Tim Danton replies: Thanks to everyone who wrote in to point out our error on the spine, and our apologies for the confusion! Regarding publishing dates, our magazine always goes on sale on the first or second Thursday of a month. That means the previous month's issue remains on sale until that point. So to avoid, say, the "February" edition being on sale in March – at which point no-one would buy it – we use the later month. Not ideal, I realise, but nor are any of the alternatives!

Readers' poll

For this month's masthead question (*see p8*), we asked our contributors to make predictions for 2025. And then asked readers to vote which of four predictions were most likely...

23% Google to de-integrate its products

5% Intel and AMD announce merger

57% Most *PC Pro* readers to have their own AI agent

15% AI proves to be flash in the pan

John Moore, commenting on Facebook, didn't think any of our predictions were going to happen so came up with his own. "The AI hype will become even more ludicrous – Heinz AI Baked Beans anyone?" Nor was Mike Webster convinced. "Is this an April Fools? None of those will happen next year IMO but if I had to pick it would be 'AI will mature to the point where most *PC Pro* readers will have their own AI agent'."

Over on Discord, Skyloop also leaned towards AI agents. "I love having a ChatGPT sidekick, and while I think AI agents are unlikely to be used by everyone, those of us who do take advantage of a real life C-3PO can only benefit." But Robert Paul Riley felt that AI would be a flash in the pan. "[I] can't see the home users paying the premium for an AI device," he wrote. "Currently [Copilot+ PC] laptops are £1,000+, most home users will splash out around £600."

Adam Jackson backed Barry's Google de-integration prediction, but purely "as a pre-emptive defence", while Tom Dickson changed the emphasis: "Google will be *forced* to open up and de-integrate its products to some *barely noticeable* degree."

And we'll give John Hind, on Discord, the floor regarding the AMD/Intel merger. "I predict major disruption in the semiconductor business: confluence of Apple's processor dominance with supply chain concerns and tariff wars will force platform owners into the semiconductor space. Intel will be up for a fire sale, but to Microsoft, Nvidia or Google rather than AMD."

Finally, we feel it only right to back our readers when they have business opportunities to share. "My newly developed AI (Ant Internet) will revolutionise 2025," wrote @NukesSix on X. "Utilising insect pheromones with potential speeds up to 3.7 teraflipflops, my AI (Ant Interweb) is stable, unhackable and compatible with all NEST technology. Openings for serious investors."

> "AI will prove useful in some situations, but turns out to be more of a naughty boy."
> **Henry Malt @artbookreviews**

> "Most likely? The AI agents. Only because I see the others as less likely."
> **Kol Tregaskes @koltregaskes**

> "If forced to choose I would say AMD merger as it's the most likely to lead to the great god, profit."
> **Keith Miller**

> "The least implausible is that most *PC Pro* readers will have some form of AI agent(s) doing some form of work for them."
> **Geoff Campbell**

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WIND in 2025

With the new year bringing the curtain down on the most used version of Windows, Barry Collins explores where consumers and businesses should head next

It's remarkable to think that a decade after its release, Windows 10 will enter 2025 as by far and away the most used version of Windows.

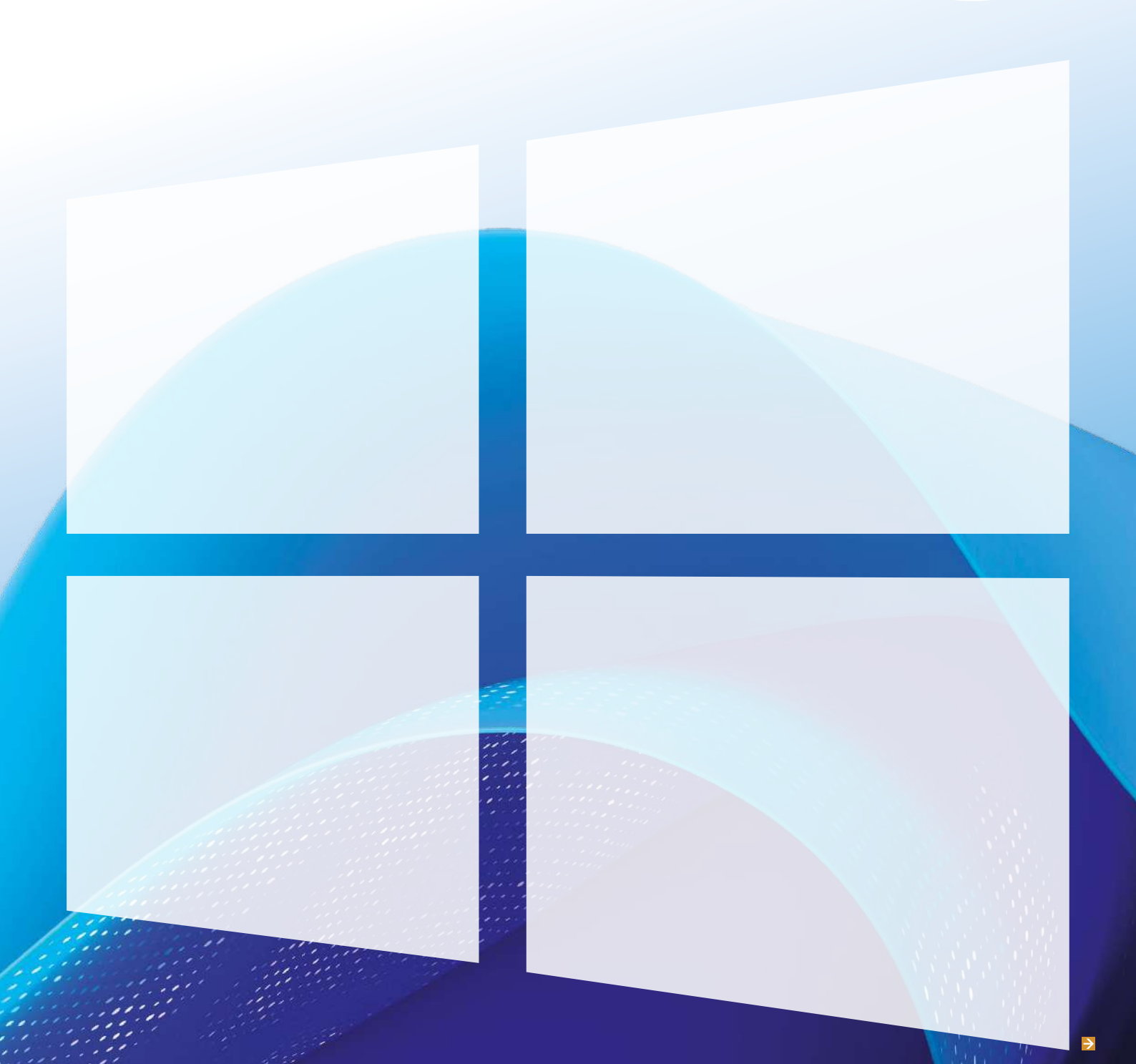
In some ways, it's a cause for a celebration. It shows that the majority of people still find Windows 10 suitably equipped for their computing needs and see no compelling reason to add to the mountains of e-waste by upgrading their computer. A win for the environment.

However, Microsoft is preparing to call time on Windows 10, with the operating system reaching end of support later this year. That will give consumers and businesses a decision to make.

Do they continue to cling to their Windows 10 hardware, grudgingly paying Microsoft for extended support? Do they upgrade to Windows 11 and, if so, which version: x86 or Arm, Home or Pro? Or should they wait for Windows 12, or maybe even eschew the very notion of running their own Windows installations and head for the clouds of Windows 365 instead?

In this feature, we'll systematically go through the options, taking the different operating systems in turn and helping you to decide which version of Windows you should be running in your home or business in 2025.

OWS



WINDOWS 10

The clock is running down on Windows 10 as we enter 2025. Support comes to a halt at the end of October, and although Microsoft has pushed Windows support deadlines back in the past – particularly when that operating system remains in widespread use – the company seems more determined to draw a line in the sand with Windows 10. Not least because there's a revenue stream attached to it.

Have no doubt: there's still a huge installed base of Windows 10 users out there, even though Windows 11 is now more than three years old. The global figures from Statcounter show Windows 10 still accounts for just over 60% of all Windows installations as of October 2024. Windows 11 is at 36%, and while the gap between the two is narrowing, it's not doing so at any great pace.

Perhaps more alarmingly for Microsoft, even the traditional early adopters of new operating systems remain stubbornly attached to Windows 10. Gamers tend to have higher spec machines than average, but Steam's hardware survey for October 2024 found that Windows 10 was still installed on 47.5% of all machines used to access the gaming service, only a tiny fraction less than the 48.8% using Windows 11.

This vast installed base partly explains why, for the first time in the history of Windows, Microsoft is offering Extended Security Updates (ESU) to consumers as well as businesses for Windows 10. Consumers will be given a year's extra security updates for a one-off fee of $30, effectively pushing the support deadline back to October 2026. Microsoft has confirmed to *PC Pro* that its Windows Defender antivirus will also keep receiving updates until at least October 2028.

Windows 10 still accounts for just over 60% of all Windows installations as of October 2024

As was the case with Windows 7, businesses can get up to three years of security patches for Windows 10, but there's a stiff financial penalty for companies that choose to linger on the operating system for the full duration. The first year of updates will cost business customers $61 per device, but that price doubles each year thereafter, meaning that by year three you'll be paying $244 per device for the security updates.

There's no financial advantage to biding your time and only paying for the ESU if a major security breach emerges that you absolutely must patch, either. If you decide to join the ESU in year two or three, you still need to pay the fee for any previous years as well.

That still won't deter many businesses from sticking with Windows 10, according to Wes Miller, research analyst with Directions on Microsoft, which offers independent IT planning advice. Miller predicts most businesses will "defer and delay".

"It's past time for organisations to begin moving to [Windows] 11," he said. "In the long run, they must get to 11, which will likely mean new hardware for many PCs."

Miller believes there are multiple reasons for businesses not moving up the Microsoft food chain. They're not upgrading to Windows 11 as "it often means replacing PCs, when organisations are being told to do more with less. Application compatibility may be to blame for some roles. Lastly, I think some organisations don't like how Windows 11's UI shifts even more and even faster than 10 did."

Upgrade options

As Miller points out, the solution for many Windows 10 users – be they consumers or businesses – isn't as simple as finally biting the bullet and pressing the button to upgrade to Windows 11.

Windows 11 famously raised the minimum system requirements significantly, meaning that a lot of Windows 10-era hardware simply isn't compatible with Windows 11. At a consumer level, there are workarounds where you can brute-force Windows 11 on to an

BELOW Windows 10 has been one of Microsoft's most successful OSes

incompatible machine. For example, the Rufus utility (**rufus.ie**), which creates bootable USB drives, has an option for Windows 11 installations that removes the requirement for 4GB+ of RAM, Secure Boot and a TPM 2.0 module. However, while you can probably live without the Secure Boot and TPM security, trying to run Windows 11 on a system with 4GB of RAM or less would be... brave.

Legacy software/hardware that isn't compatible with Windows 11 is another potential blocker. Windows 11 Pro allows you to virtualise a Windows 10 instance using Hyper-V, among other virtualisation options, but that is something of a sticking plaster option.

Ultimately, the end of support for Windows 10 really should be the nudge to start considering longer-term solutions. The question is, where to next? Windows 11 is now well established, but there are different versions to consider, including the much improved Windows on Arm. Or perhaps the cloud-based Windows 365? And is there any prospect of Windows 12 any time soon? We'll consider all of these in turn.

The Honeyball view on Windows 10

We asked Jon to give his very personal view on what to say to people who are still relying on Windows 10 for business or home use

If you work in the IT industry, I suspect you will have heard the adage "if it ain't broke, don't fix it" more than once in your career. While it sometimes holds true, it fails when things start gathering a layer of dust. By this time, you have little or no idea how to fix things when they go wrong.

Windows 10 going out of support is a big deal, if only because there's a lot of perfectly usable hardware out there that can't be moved to Windows 11. And while this might seem "skipware", it raises the question of what to do.

The answer is actually simple if there is no update path: either cough up the money for extended support or change your hardware. It really is that straightforward.

For the home user, the extended paid-for support is available for just one year, and although it will put off the replacement day, it doesn't really do so in a meaningful way. It's time to get new hardware that runs Windows 11 and transfer everything across. You can either keep the old box disconnected from the network and running Windows 10, or move to a modern Windows-alike Linux. Mint is my preferred choice.

If you want to retarget the computer to Linux, then use the facilities to create a boot USB drive for the Linux Mint installation. Then try it! You'll soon know if it works well on your hardware and can decide whether you get on with it well enough for a permanent move. Once this has been done, the tools are supplied to steal away disk partition space from the Windows installation, and to create a dual boot environment. This will allow you to boot back and forth between Windows and Linux Mint as you transition from one to the other.

Moving your world across is never going to be easy, and I confess I prefer a "clean start" approach. Making sure you have backups in place, and copies of all critical data, is the key point. Cloud services such as Gmail, Hotmail, OneDrive and Dropbox are all extremely helpful in this context.

This is also the perfect time to take a long, hard look at how your data is stored. Are you relying on this one Windows 10 computer, and is there an existing workable disaster recovery plan in place for it? And do you know that this will work?

In many home use cases, I suspect this isn't the case, and there's an almost endless supply of hope and finger-crossing involved. If you aren't using cloud services such as Dropbox, now is the time to start thinking about it.

For businesses, Microsoft is offering three years of support on a rising price plan. Tread carefully. This should only be used in the most extreme cases: you might have some industrial control software that only runs on Windows 10, and for which the developer hasn't moved to Windows 11 support. This rings all sorts of alarm bells for continuity and risk planning in the business, and while you could move to running the mission-critical app in a locked-down Windows 10 virtual machine running on Windows 11, this is going to be a mess.

ABOVE If you have old hardware that won't run Windows 11, now is the time to upgrade

If you have a mission-critical app that won't run on Windows 11, then the same rules apply but those sirens are now wailing loudly. You have six months to sort this out before opening the cheque book in the hope of delaying the inevitable.

Look carefully at your estate of hardware. How ageing is it that it won't run Windows 11? Can you swap out the computer component and reuse the screen, mouse and keyboard? If so, the new Windows terminal box from Microsoft – the Windows 365 Link, which we cover on the following page – might be just the ticket if you're prepared to make the leap into cloud-hosted Windows sessions.

Yes, it comes at a high cost. But trust me, so does running an old estate of PCs with all the insecurities and unpredictable failures that will become so tiresomely frequent.

WINDOWS 11

If the end of support for Windows 10 is prompting you to buy new hardware and you're staying within the Windows ecosystem, you're going to end up with Windows 11 in one form or another. But the choice here isn't as simple as it once was.

There's now a debate to be had over "sticking" with the x86 version of Windows 11 or plumping for Windows on Arm. Within those two camps, there's a choice to be made between Home and Pro versions, at least for consumers. And you might even be thinking about running Windows 11 from the cloud (see box on Windows 365, opposite). Let's start breaking down the decision-making process.

x86 or ARM?

A year ago, Windows on Arm was looking like the version of Windows with a few too many compromises. Now, it's a much harder choice – assuming you're thinking of buying a laptop rather than a desktop that is.

Windows on Arm has yet to make any significant inroads on the desktop, bar a couple of developer systems. In the fullness of time, it might arrive on mini PCs or all-in-ones (keep an eye out for next month's feature showcasing all the new technology from CES 2025), but for now it's largely confined to laptops.

However, it says everything about the rise of Arm chips in laptops that the *PC Pro* A-List has Arm-based machines as the top picks for the Premium Laptop, Business Laptop and Copilot+ Laptop categories, albeit the Premium Laptop is an Apple MacBook Pro.

The biggest advantage of the Arm architecture is power efficiency. The A-Listed Lenovo ThinkPad T14s Gen6 (Snapdragon) lasted almost a full day in the PCMark Application benchmark, which runs a mix of Office and web-based apps. That's not a full working day, that's a full day – 23hrs 39mins of constant usage. And though we've seen recent Intel processors making great strides in power efficiency, they're unable to reach those heights.

The 12-core Qualcomm Snapdragon X1E-78-100 system-on-a-chip inside the ThinkPad isn't light on muscle, either. It matched Intel's Core Ultra 7 in the Geekbench 6 single-core test, and hammered it in the multicore section, although Intel had the slight edge in Cinebench 2024. Certainly, for everyday work apps, there's no need to fear running Windows on Arm.

That's partly because app compatibility has grown much healthier. It's a stat that might have fallen victim to Stockholm Syndrome, but Microsoft claims that aggregated app usage data from Copilot+ PCs in several countries showed that owners were spending more than 90% of their time in apps coded specifically for the Arm platform. That list includes the full Office suite, Dropbox, Slack, most of Adobe's Creative Suite, Spotify, Netflix, Visual Studio Code and almost all of the well-known web browsers. Even those apps that aren't yet native will likely run fine with the Prism x86 emulation software.

"Windows 11 on Arm has significantly matured, with improved software compatibility, including native ARM64 apps (eg, Microsoft Office, Google Drive), and better x86/x64 emulation," said Kashif Nazir, technical manager at Cloudhouse, a company focusing on application compatibility and cloud enablement. "Arm-based devices offer exceptional portability, battery life and cloud-first integration, making them ideal for mobile workforces, lightweight business tasks or cloud-reliant environments. However, businesses relying on specialised or legacy software should verify compatibility before migrating."

Gaming is the one major area where the Intel/AMD axis still has a big advantage. That's largely because few games run natively on Arm, forcing them into the frame-rate-sapping emulator. Nor will you find an Arm-based Windows laptop with dedicated graphics chips, instead relying on Qualcomm's integrated Adreno GPUs. If gaming is even part of the reason for buying a new laptop, it's better to stick with the x86 machines.

Sticking to x86 doesn't necessarily mean huge compromises on battery life, either. As we mentioned, Intel has been working hard to match the renowned Arm power efficiency, and the Intel-based Asus Zenbook S14 we reviewed recently (*see issue 362, p46*) lasted for just over 19 hours in the light-use battery test. That uses one of Intel's new Core Ultra 200V processors, which are geared towards efficiency rather than out-and-out performance, but it's hopefully indicative of a new era of all-day battery life in x86 laptops that aren't being thrashed with games or other high-intensity tasks.

ABOVE Lenovo's Arm-based ThinkPad T14s Gen6 offers stunning battery life

Arm-based devices offer exceptional portability, battery life and cloud-first integration

Pro or Home?

If you're buying a new PC or upgrading from Windows 10, it's worth a quick recap of the differences between the Home and Pro versions of Windows 11. Both the x86 and the Arm-based versions of the OS support Home and Pro editions, so the information below applies equally to both.

Obviously, if you're buying for a business, then Pro is the only realistic choice. You might not be too bothered about technically breaching Microsoft's licensing terms by using a Home licence for business, and the chances of you being caught are minimal, but there are several business-specific features that are excluded from the Home version. For example, Home machines can't join a domain, support Group Policy or be managed with Windows Intune.

It's really only small businesses or sole traders who would even consider buying a Home licence over Pro anyway, but even at this level, where you might not have any central IT management, there are reasons to stick with Pro. BitLocker device encryption is one big absentee from Windows Home, meaning that if you were to leave a work laptop on a train or have it stolen in a burglary, your data should be protected.

Virtualisation is another Pro-only feature. If you want to keep old apps running in a virtual OS or maybe run a Linux coding environment, you can do so with Hyper-V. Third-party virtualisation software such as VirtualBox does run on the Home edition, but it's much simpler to use the native Hyper-V in most scenarios. Windows Sandbox, which allows you to test untrusted software in a separate instance from your main desktop, is another feature that you won't find in the Home edition.

If you think you're going to need Pro, it's normally cheapest to have it installed at the point of purchase. You can upgrade in place from Home to Pro in Windows 11, but it's a punch £120 if you go through the Microsoft Store. You can find licences cheaper online, but these aren't always legitimate; you're better off buying through the *PC Pro* Store, where it's currently £50 (*see p35*).

Once you have your activation key, go to Settings | System | Activation and change the product key manually. The features are already installed with the OS; applying the activation key just unlocks them. All of your data and apps should remain untouched.

BELOW The Windows 365 Link is Microsoft's take on the mini PC

WINDOWS 365

If the cost of rolling out new hardware is one reason businesses are stalling on Windows 10, Windows 365 provides a potential solution.

Now an established part of the Microsoft lineup, Windows 365 is a virtual Windows instance hosted in the cloud, accessible from a range of internet-connected devices, including other Windows desktops, iOS or Android devices. Windows 365 subscribers can currently choose between Windows 11 and Windows 10 as their cloud operating system, although presumably Microsoft will phase out Windows 10 as an option when it reaches end-of-life.

While Windows 365 may spare you the upfront cost of new hardware, the long-term costs need to be considered carefully, particularly if you need one of the punchier specs. The Basic plan costs only £29 (exc VAT) per user per month, but for that you only get two virtual (and unspecified) vCPUs, 4GB of RAM and 128GB of storage. At the other end of the scale, the Premium version delivers four vCPUs, 16GB of RAM and still only 128GB for a much fruitier £61 per month. That's a £700+ a year investment for not a lot of PC.

There are business benefits to Windows 365 compared to running your own hardware. There's reduced energy costs, no direct hardware support costs, and Microsoft takes care of the security provision. For staff working from home, you can let them remotely access their work desktop from their personal devices, without worrying about any security compromises. And for businesses that are hotdesking or employing a lot of temporary/short-contract staff, it could prove more cost-effective than kitting out offices with new PCs, although staff will still need some form of hardware to access the service from.

That device could even be a (whisper it) thin client from Microsoft itself. The company recently announced the Windows 365 Link – a mini PC similar in stature to the Mac mini – which is a client designed to exclusively access Windows 365. It's small, fanless and wakes "instantly" from sleep. David Weston, vice-president of enterprise and OS security at Microsoft, told The Verge that the way to think of it was as a "super hardened" version of Windows. "Everything that runs is signed by Microsoft and it's isolated in sandboxes," he added, comparing it to something like the Xbox in terms of its closed nature.

The Link can support multiple displays, and has two USB-A 3.2 ports and a single USB-C 3.2 port, as well as DisplayPort and HDMI outputs. It has both Ethernet and Wi-Fi 6E connectivity, as well as Bluetooth 5.3 for connecting wireless peripherals. It will go on sale in April, but while we know it will cost $349 in the US, Microsoft hasn't yet confirmed its UK price. If you're in a rush, Dell and Lenovo offer similar thin client devices.

Yet even on the most Basic plan, you're still looking at a year-one cost in the region of £700 for a Windows 365 Link device. Wes Miller isn't sure that is likely to lure many businesses – and it remains business-only for now – that have yet to make the move to Windows 11.

"I don't think a customer who has held out on migrating to 11 to this point is likely a good candidate to pay the premium price for Link, as well as the premium price for Windows 365," he said. "Some may move that way, but it will be a small minority of customers."

WINDOWS 365 OPTIONS

	Basic	Standard	Premium
Price per month (exc VAT)	£28.80	£38.10	£61.30
vCPUs	2	2	4
RAM	4GB	8GB	16GB
Storage	128GB	128GB	128GB
Users	Up to 300	Up to 300	Up to 300

WINDOWS 12?

Another reason to add to the growing list of excuses of why people are sticking with Windows 10 is the uncertainty of what's happening with Windows 12 – or whatever the next major version might be called.

The cadence of Microsoft's Windows version releases has become entirely unpredictable. Windows 7 was released in 2009, Windows 8 followed in 2012, and Windows 10 in 2015, but that seemingly ended the three-to-four year gap between major versions. Windows 11 was something of a shock drop in 2021, because although it had been six years since the previous release, Microsoft had previously suggested it wasn't planning a major new version, but would instead keep providing cyclical updates for Windows 10. Now nobody is quite sure when or whether Windows 12 will make an appearance.

An obvious opportunity for a major release has seemingly passed. The flurry of AI features added to Windows 11 in the past couple of years, not least the controversial Recall feature, would have given Windows 12 a clear point of differentiation from Windows 11. Instead, Microsoft opted to go down the Copilot+ PC route, making some of those features available exclusively to PCs that meet certain NPU requirements.

A very underwhelming set of new features for the annual Windows 11 24H2 release maybe hints that Microsoft is saving standout new features for Windows 12, perhaps for announcement in 2025. But if Microsoft does announce a new OS, it will give those on Windows 10 an even greater incentive to hold fire on upgrades until Windows 12 machines are on the market, which won't be until the back end of the year at the very earliest, pushing them past the October cut-off date.

"Much has been made of a potential [Windows] 12, but if Microsoft is having this much difficulty getting organisations off 10 to 11, in this economy I have a hard time believing a shift to 12 or any other brand will do anything to speed the shift, clear out stragglers, etc," said Wes Miller from Directions on Microsoft. "It honestly just becomes a marketing pushpin to try and generate excitement. But I don't think that matters for business customers."

ABOVE Microsoft has made much of Copilot+, making features available only to those PCs that meet certain requirements

BELOW Judging from Surface devices, Windows 12 might require a touchscreen

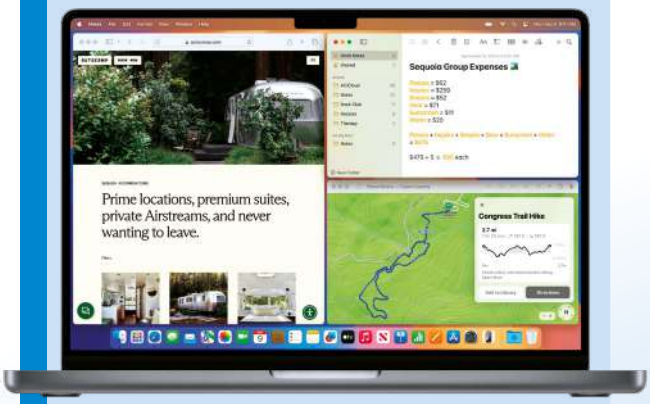
Nobody is quite sure when or whether Windows 12 will make an appearance

The Apple option

If nobody's quite sure when the next version of Windows will arrive, you can be more certain about the cadence of macOS. Although the annual new versions of macOS are arguably comparable to Windows' annual updates, they have been as regular as clockwork for over a decade and don't pull up the ladder on old Mac hardware that aggressively.

That said, with next year marking five years since Apple launched its own M1 silicon, it's possible that macOS 16 will cease support for Intel-based processors. That would be a significant milestone, and one that underlines how Apple has mastered the shift to Arm-based silicon at a much faster lick than Microsoft has. This despite Microsoft releasing the Arm-based Surface RT back in 2012, eight years before Apple bet the house on Arm architecture.

Even though the Arm-based Windows machines have delivered big improvements in performance and battery life in recent months, Kashif Nazir from Cloudhouse believes that Apple is still the pacesetter. "Apple's long-standing dominance in Arm computing through its Apple silicon (M1, M2, and beyond) highlights the potential of the Arm architecture," he said.



"By combining vertical integration (hardware and software co-design) with unmatched performance and efficiency, Apple has set a benchmark that Arm-based Windows devices are working to match. While Windows on Arm has made significant strides, particularly in power efficiency and portability, it still trails Apple's ecosystem in terms of performance optimisation and software ecosystem maturity."

For businesses, switching platforms comes with all manner of other considerations – including staff training, device management and software compatibility – that all have to be carefully weighed up before even thinking about jumping horses. For consumers, the hurdles are less onerous. It's arguably never been easier to switch between Windows and Mac (and vice versa), what with cloud services and the huge cross-compatibility of major applications.

Gaming remains the Mac's biggest blackspot, with Apple's own GPUs failing to match the performance of dedicated Nvidia/AMD GPUs, and game availability still very restricted. Nevertheless, cloud gaming services such as Nvidia's GeForce Now can bridge the divide – albeit at a significant price.

READER OFFER

WINDOWS 11 PRO UPGRADE for £49.99

Perfect for upgrading from Windows 10 or 11 Home, this licence will upgrade you to Windows 11 Pro for only £49.99

SAVE 58%

■ tinyurl.com/win11pro-upgrade

Want to upgrade from Windows 11 Home to Windows 11 Pro? Or perhaps you're building a new PC from scratch, or looking to move up from Windows 10 Home?

Whatever your motives, a Windows 11 Pro upgrade licence is a great choice. The first reason is simple: price. Microsoft charges £119.99 for a retail licence of Windows 11 Home, a staggering £219.99 f Windows 11 Pro, and £119.99 for its own upgrade licence from 11 Home to Pro. By choosing this licence – and avoiding the many dubious sourc of licences you may find online – you cut that price substantially.

Note that the upgrade only works from an activated copy of Windows 11 Home, so if you're currently using a Windows 10 Home system then you'll need to upgrade from that to Windows 11 Home before this upgrade can work. Using an older version of Windows? Then see our OEM licence offers below.

WINDOWS 11 PRO 1-PC LICENCE for £79.99

SAVE 64%

■ tinyurl.com/windowspro11

Whether you want to upgrade your PC from Windows 7/8 to Windows 11 or run Windows 11 as a virtual machine, a 1-PC licence is a great choice. It offers a huge saving over Microsoft's pricing and you avoid buying a dodgy licence online.

While a 1-PC licence is tied to a single PC, it will continue to work even after major system upgrades (including a change of motherboard if you "kill" the PC in your Microsoft account). Plus, if you set up a VM, you can transfer your licence across to another VM on the same PC.

In fact, a 1-PC licence is perfect for any kind of fresh install you can think of. It's the obvious choice for those building a new PC from scratch – the lower price means you save money on the cost of your build, which could be reinvested in more powerful hardware.

A 1-PC licence also fits the bill should you want to run Windows alongside another operating system – either in a dual-boot configuration or in a virtual environment such as VirtualBox. Mac users can use a Windows 11 Pro licence within Parallels Desktop for Mac or VMware Fusion.

Windows 11 Pro includes all the features from Windows 11 Home, plus BitLocker system-wide encryption, remote login support and Hyper-V to run virtualised operating systems within Windows without the need for extra software (great for running VMs such as an insider build of Windows 11, a Linux distro or older editions of Windows).

Please remember to check your PC can run Windows 11 before purchasing.

ALSO CONSIDER Windows 11 Home 1-PC licence for £59.99 **SAVE 50%**

INSTANT EXPERT

DAVINCI RESOLVE

Edit and render videos like a pro. Nik Rawlinson shows you how to hit the ground running in the powerful free editing suite

There are plenty of video-editing tools out there, but DaVinci Resolve is unique in offering a comprehensive professional-grade workflow completely free of charge. It's a well-established tool, too: the software turned 20 last year, and has been used on big-name Hollywood films including *Bohemian Rhapsody*, *La La Land* and *Spectre*.

If you've ever used another non-linear video-editing suite, such as Premiere Pro or Apple's Final Cut Pro, you should have no problem getting started with DaVinci Resolve, as it uses industry-standard tools and workflows. If you're coming from a simpler tool such as Windows Movie Maker or iMovie, the interface might seem daunting at first, but don't be put off. Spend an hour or two exploring what DaVinci Resolve has to offer and you'll soon start to feel at home – and our top five tips on these pages will help you reap high-quality results from the word go.

Is it really free?

Yes, the standard edition of DaVinci Resolve is completely free, with no ads or in-app purchases, and you can use it for as long as you like, to make any type of video. It will run on any PC running Windows 10 or 11, or any Mac running macOS Monterey or later – although bear in mind that video editing is a resource-intensive process, and if you try to run it on lightweight hardware the experience may be sluggish.

There's also a Linux edition, for which the publisher recommends a recent edition of Rocky Linux or CentOS, and an iPad version that runs on tablets with an A12 Bionic chip or later; see **tinyurl.com/365davinci** for download links.

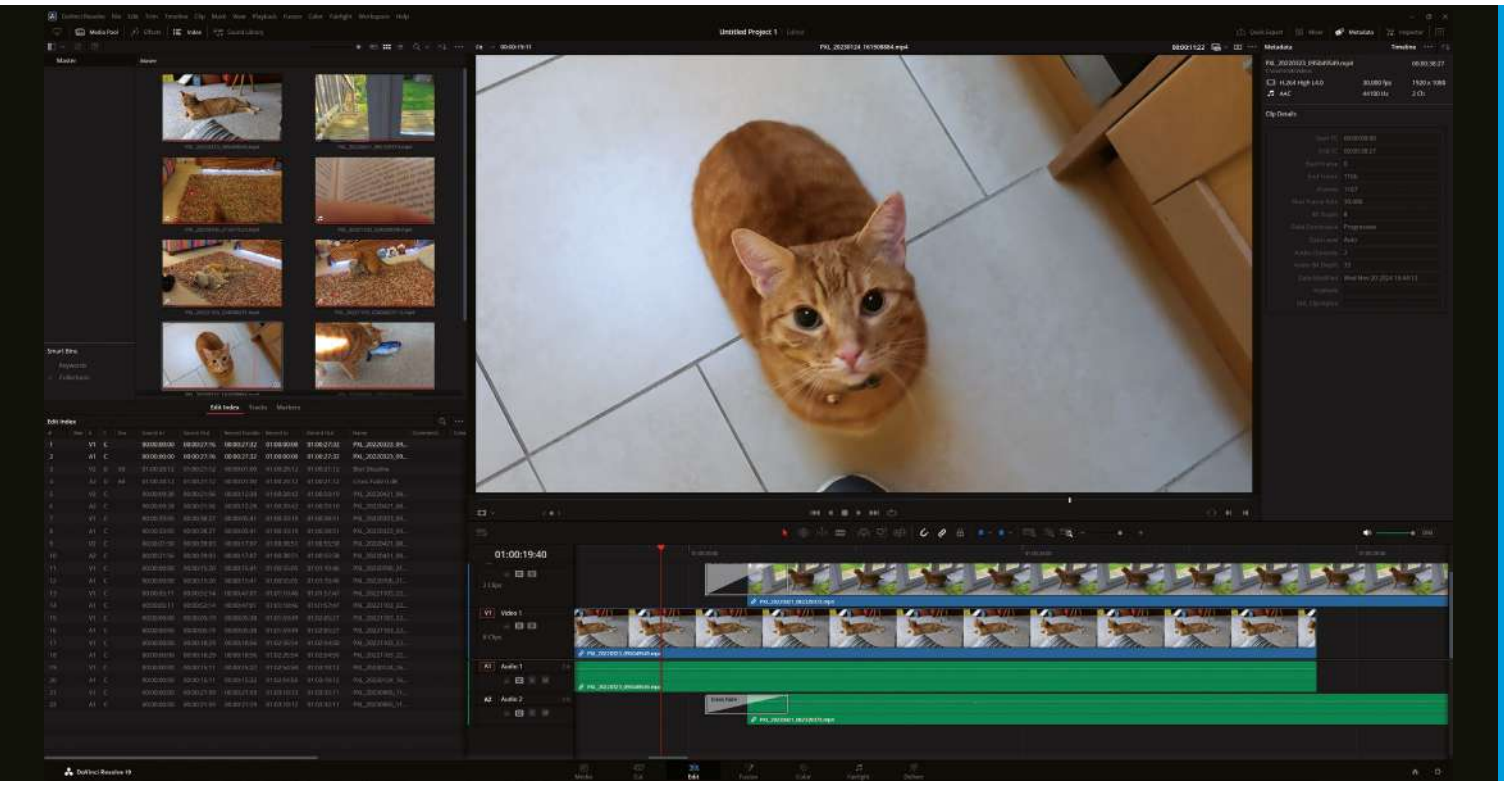
Whichever platform you're using, you get an extensive set of tools for editing and enhancing video clips in all popular formats, assembling them into a complete film, and exporting the finished product for online sharing or high-quality distribution. Unless you're a film and TV professional, it will do everything you need – although for those who do fall into that category there's also a high-end commercial version of the software called DaVinci Resolve Studio, which adds enhanced tools for colour grading, media management, speech transcription, subtitle generation, audio editing and more. At $295 it's a big step up from the free edition, but for what you get it's still a very reasonable price.

1 Import and organise your footage with bins

Putting together a project in DaVinci Resolve starts with importing your raw footage into the program. You can add files to the Media Pool by dragging them from the Windows File Explorer to the upper left panel in the Resolve interface, or by clicking the Import Media button above the Media Pool panel (you can also use the keyboard shortcut Ctrl+I).

If you're only working with a handful of clips you can keep them loose in the Media Pool; for bigger projects it can be helpful to organise your clips into different "bins", representing different shoots or subjects. To create a bin, press Ctrl+Shift+N, or select New bin from the File menu.

As well as helping you manage your clips in an individual project, bins offer an easy way to reuse a set of assets across multiple productions. To export a bin for future use, click Media on the toolbar at the bottom of the DaVinci Resolve window; this will change the main view from editing to media management, and you'll see a new sidebar in the lower-left quadrant showing your existing bins. Right-click on one and click Export bin to create a saved copy that you can easily import into future projects, using the Import option on the File menu.



Note that exporting a bin doesn't create new copies of the clips it contains. This is a good thing, as doing so could waste a lot of disk space; rather, a saved bin contains links to the original assets, in whatever location they were in when it was created. After you've saved a bin, therefore, you should avoid moving the original media it refers to – otherwise you'll have to locate the files by hand next time you access it.

2 Working with multiple tracks

When you first start working with a non-linear editing tool like Resolve, your instinct might be to line all your clips up on a single track of the timeline and trim each one down to create the sequence you want.

However, you can work more quickly, and with more flexibility, by layering your material across multiple tracks. For example, in the screenshot to the right, we're transitioning between a wide shot and a tighter shot showing the main action. Rather than splicing them directly together we've overlapped them, with the wide shot on the lower track and the tighter shot on the track above it. When we play the video, only the uppermost clip is visible, so we don't need to waste time precisely setting the out point of the lower clip.

We can also now independently reposition, trim or extend each clip by dragging it on its own track. To adjust the in and out points of a clip on the timeline, just position the mouse cursor over its start or end, then click and drag left or right.

Even though there's no hard junction between the two pieces of raw footage, we can also still apply transitions between them. You'll find these options in the Cut module, accessible from the toolbar at the bottom of the screen. To apply a transition from the library, click the Transitions tab at the top of the window – replacing the Media Pool – then drag your chosen transition from the pane onto the uppermost media object. You can then fine-tune its behaviour as desired in the right-hand sidebar.

ABOVE Using multiple tracks helps you make quick adjustments

3 Sound and vision

When you place a video clip on the Resolve timeline, its audio component appears as a waveform inside a blue track that runs along the bottom of the video frames. By default, the video and audio are linked, so if you adjust the position or length of one, the other will follow identically, even though it's situated on a separate track.

If you don't want this to happen, right-click either the video or audio

clip and select Unlink Clips at the bottom of the context menu (alternatively, you can press Ctrl+Alt+L to unlink the selected clips). The video and audio clips can now be edited independently, without affecting each other.

You can also use this technique to delete the video or audio portion of a piece of footage while leaving the rest in place. However, if you just want to silence the audio, a neater approach is to leave it linked and simply reduce the volume to zero. To do this, click on the line that runs horizontally through the centre of the waveform and drag it down to the bottom of the waveform container. The volume will be reduced to -96.86dB and the visual representation of the waveform will disappear. You can drag this line only part of the way down to reduce the volume slightly in your overall mix, or move it up to increase the volume.

You can also use mouse controls to make audio fade in and out. When you hover your mouse pointer over a waveform clip, handles will appear in the top corners over the in and out points, and you can drag these inwards to create a fade; a diagonal line shows the overall volume level as it transitions from 0% to 100%, or vice versa. If your fade is long enough, you'll see a dot at the half-way point on this diagonal (if you can't see this, hold Alt and scroll up on your mouse wheel to zoom in on the timeline). This dot is another handle, which you can drag to adjust the shape of the volume curve, so it fades out more gradually or more suddenly, as you can see on the two fades in the screenshot above.

4 Correct colours using keyframes

It's not unusual for a collection of clips to exhibit significant colour differences – for example, if they were shot in different weather conditions or at different times of day. Applying judicious colour and lighting corrections can reduce these differences and make your finished project feel more like a cohesive whole. This is easy to do in DaVinci Resolve, and by using keyframes you can automate the adjustments so that they fade in subtly at the points you desire.

Once you've imported your assets and arranged them on the timeline, click Color on the bottom toolbar to switch to the colour-adjustment view. If you have any experience of applying colour adjustments to still images using a program such as Photoshop, you'll find some of the tools you encounter here immediately familiar, such as the main Curves control that takes centre stage at the lower centre of the screen. This shows a live histogram, representing the intensity of the individual primary colour elements – red, green and blue – across the current frame, with darker tones (shadows) to the left and lighter tones (highlights) to the right.

Now click one of your footage thumbnails immediately below the playback window, or click a piece of footage on the timeline, and it will be displayed in the playback window. You can use the controls below the main preview window to get a live view, or drag the playhead in the Keyframes panel to advance through the frames that make up the clip.

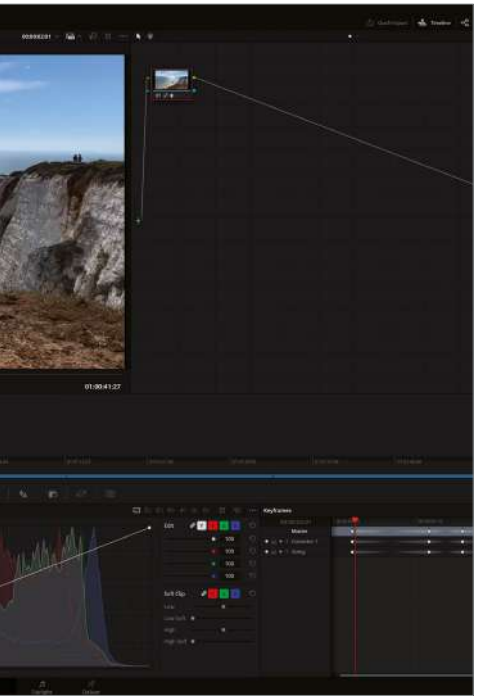
ABOVE LEFT You can adjust the rate of attack of audio fades

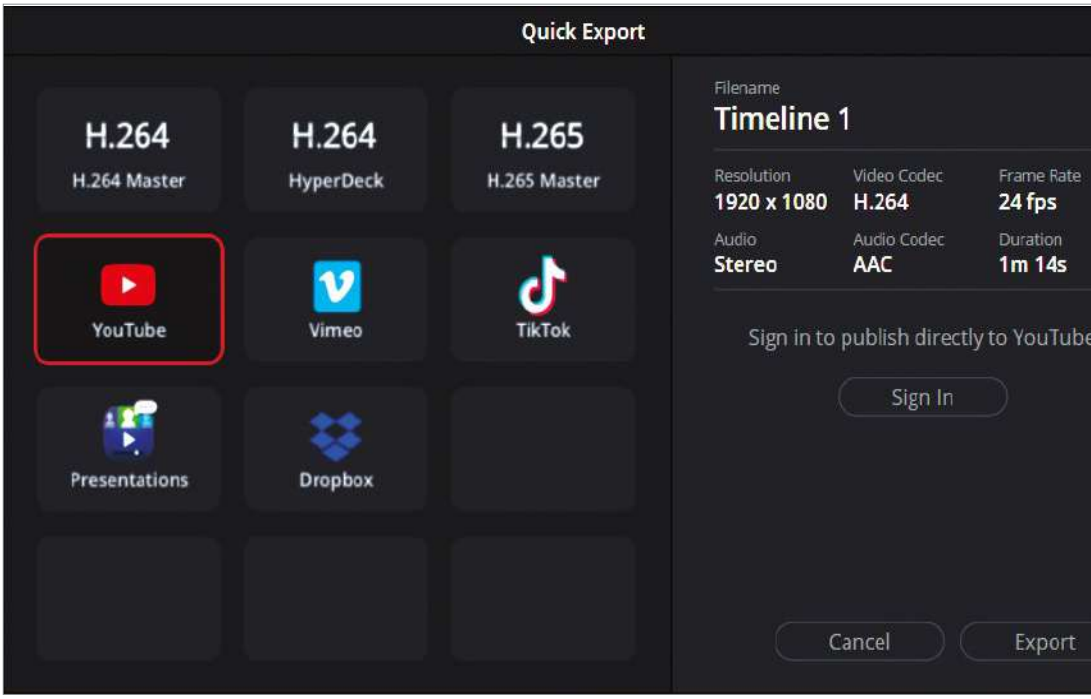
ABOVE Using dynamic keyframes lets you gradually apply adjustments

When you notice something you want to fix, such as unnatural tones, burned out details or areas lost in the shadows, stop dragging. Back up slightly, then right-click in the Keyframes window and add a new dynamic keyframe, which will be dropped in line with the playhead. Now scroll forward to the point where you want the adjustment to take full effect, and insert another dynamic keyframe.

Now, with the playhead on the second keyframe, you can make whatever adjustments you wish using the controls within the Color module. For example, you might drag the handles within the Curves control to increase or decrease contrast. Or you could drag the centre points on the colour wheels to adjust the tone of the highlights, shadows and other

UNLESS YOU'RE A PROFESSIONAL, IT WILL DO EVERYTHING YOU NEED





aspects of the frame. It's worth spending some time experimenting to see what you can do, and how combinations of different adjustments affect the overall look.

Once you've got a setting you're happy with, you can scroll back and replay the whole video. The footage will look as it did before until playback reaches the first keyframe; then your corrections will start to fade in, until they're fully applied at the second keyframe. They'll remain active until the end of the clip, or until you create another keyframe and make further adjustments.

If you later want to tweak your changes, just return the playhead to the second keyframe and change the settings – or, if you want to adjust the timing of the change, you can move the keyframes themselves.

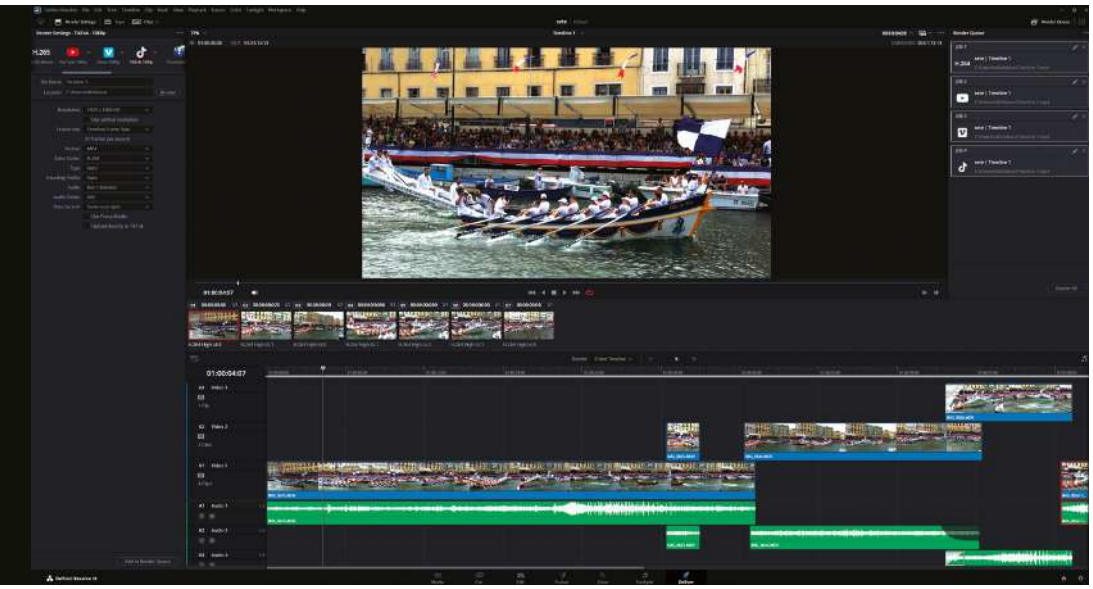
5 Export and share

You can always preview your video directly from the timeline, but you might also want to quickly export a rough cut during the editing process, so you can view it in a different context or share it for feedback before the final render. To do this, click Quick Export on the top toolbar, then select a preset from the options that appear, which include formats suitable for YouTube, Vimeo and TikTok. DaVinci Resolve can even handle the upload for you if you sign in to your account through the application.

You can use the same process to share it with the world, but if you switch to the Delivery module (click it on the bottom toolbar) you'll find plenty of additional settings in the Render Settings sidebar.

ABOVE It's easy to create a version of your video for distribution

BELOW You can stack up several versions to be rendered in sequence



Start by either picking a preset or selecting Custom Export; then, choose whether you want to output your entire assembled video as a single file, or render an individual clip for each piece of footage in your production. Then it's time to select an output format and codec, and make any other adjustments you wish to the format, such as setting your preferred output resolution and even the pixel aspect ratio (square or cinemascope).

Once you've selected your desired settings, click "Add to Render Queue" at the bottom of the Render Settings sidebar. Your job will now appear in the Render Queue panel on the opposite side of the screen, and you can start rendering right away by clicking the Render All button.

However, if you want to create multiple versions of the video – perhaps for different platforms – then you can at this point return to the Render Settings sidebar, set up another job with different settings, and add this to the queue. We added four jobs to the queue – one full-quality version of our video and three smaller versions optimised for different social media platforms. When we click Render All, DaVinci Resolve will set about creating all four versions in sequence. This may take a while, but we can go and do something else while the software works through the render queue.

One last tip: if you're producing multiple renders in one go, make sure you specify a unique filename for each one on the Render Settings File tab. If you tell the software to create multiple exports with the same filename and extension, the later renders will overwrite the earlier ones.

EMULATION

MAKING WINDOWS ON ARM GREAT AGAIN

RIGHT The Surface Pro 11th Edition is powered by Snapdragon chips

HOW DO THE LATEST LAPTOPS AND MACS RUN INTEL SOFTWARE ON THEIR ARM PROCESSORS? DARIEN GRAHAM-SMITH EXPLORES THE WONDERFUL WORLD OF EMULATION

Microsoft's "Copilot+ PCs" are supposed to usher in a new era of AI-assisted computing, but they're historic in another way, too. With surprisingly little fanfare, Microsoft has for the first time endorsed a range of third-party laptops based on a mixture of AMD, Intel and Arm processors.

This isn't the first time the firm has offered a version of Windows that runs on the Arm architecture, but it might be the first time the idea succeeds – because the OS now includes an emulation layer. Conceptually this is much the same as the clever software tools that let you tinker with a virtual BBC Micro inside a web page, or revisit old Amiga games on your phone. In this case, though, it's designed not for historical purposes, but to allow the latest Intel-native apps to run on the Arm hardware.

It's a similar approach to what Apple did with the launch of its M-series processors (*see p43*), and it promises the best of all worlds, combining Windows' huge existing software library with the efficiency and battery life of Arm. If you're curious as to how we've got here, and what emulation could mean for your next laptop, read on.

NO EMULATION, PLEASE – WE'RE WINDOWS

Microsoft has a long history of developing Windows for multiple different hardware platforms. In the 1990s you could buy versions of Windows NT not only for the familiar Intel x86 platform, but also for rival workstation and server systems such as PowerPC, DEC Alpha and MIPS – each with its own proprietary instruction set architecture (ISA). In the early 2000s, support was added for Intel's 64-bit Itanium platform too.

However, Microsoft made no attempt to bridge the gap between these different platforms. Each edition of Windows only worked with software and drivers that had been compiled for that particular architecture. The result was a highly fragmented market that wasn't ideal for anybody – certainly not Microsoft, which was at one point simultaneously developing and supporting Windows for at least five different hardware platforms. Partly for this very reason, the competing ISAs gradually died away, and by 2010 Windows was only available for the Intel architecture.

BELOW Remember the Surface RT, Microsoft's first attempt to put Windows on Arm?

THE WOW64 STARTS NOW

Ironically, while Microsoft was jettisoning non-Intel architectures, it rapidly found itself having to build new emulation features into Windows. In 2000 AMD introduced the AMD64 architecture, an extension of Intel's x86 ISA that enabled support for 64-bit addressing – meaning PCs could use more than 4GB of RAM, and work more quickly and efficiently with larger data structures.

At first Microsoft ignored AMD64, seemingly believing that the 64-bit future lay with the Intel Itanium architecture. But while IA-64 was a completely new ISA that couldn't run x86 apps, AMD64 included native support for 32-bit versions of Windows and applications, making it a much more attractive choice for general-purpose computing. By 2004 Intel had started licensing AMD's 64-bit extensions for use in its own x86 chips, under the not very imaginative name "Intel 64". Itanium fell by the wayside, and the new x86-compatible 64-bit platform – now commonly known as x86-64, or just x64 – started to become ubiquitous.

At this point you might be wondering: if the whole point of x64 was compatibility with older x86 code, where does emulation come in? The answer lies in the interaction between the OS and the hardware. Taking advantage of the chip's 64-bit capabilities required a 64-bit edition of Windows: the first of these was Windows XP Professional x64 edition, released in 2005, and from Vista onwards all releases of Windows were offered in both x86 and x64 flavours.

But because 64-bit Windows used larger address spaces, additional registers and other extensions, it wasn't directly compatible with programs designed for the 32-bit version of the OS. To allow older applications to run, Microsoft designed a simple emulation system called WoW64, short for Windows-on-Windows 64-bit – along the same lines as the old WoW32 component included in Windows NT that had allowed the 32-bit OS to run old 16-bit applications.

The WoW64 framework includes a set of libraries that translate 32-bit operations into 64-bit compatible forms, and automatically "redirects" certain operations to keep 32-bit and 64-bit components apart. For example, when 32-bit apps try to access the Registry, the OS redirects operations to a separate 32-bit datastore, and 32-bit apps install and run in a folder called "Program Files (x86)" – aside from the main "Program Files" folder, which is reserved for 64-bit code. The actual program code, however,

runs on the processor unmodified – so there's almost no impact on performance or system resources.

WINDOWS ON ARM

You could make a case that WoW64 is the world's most popular emulation layer, since it's included in almost every copy of Windows in use today. However, it's not exactly an ambitious system, and some would say it barely qualifies as emulation at all, since rather than emulating a different CPU it merely emulates a different version of Windows. The same can't be said for Microsoft's most recent emulation project, which aims to allow Windows apps written for the Intel architecture to run smoothly on a computer with an Arm processor.

Running Windows on Arm processors isn't a new idea. Cast your mind back to 2012 and you may recall a little computer called the Microsoft Surface. This compact convertible was built around an Arm-based Nvidia Tegra 3 T30 chip – chosen over Intel for its superior power efficiency, and hence battery life – and ran an Arm-based version of Windows called Windows RT.

At first glance you could easily mistake Windows RT for Windows 8. The two operating systems were launched simultaneously, and (for better or worse) offered very nearly identical interfaces. However, as with previous non-Intel editions of Windows, RT could only run applications specifically compiled for its hardware platform. You couldn't even attempt to install Intel apps, as the Surface was restricted to software offered via the new Windows Store.

Microsoft spun these restrictions as a plus point: viruses and other security threats wouldn't work on the new platform, and the sandboxed Store framework helped block off new exploits. The simpler, cleaner app model also meant the operating system could be much more streamlined and efficient. Even so, the almost total lack of compatible software made RT a lame duck, and when Windows 10 was released in 2015 the Arm platform was quietly dropped. It seemed as if the idea of Windows on Arm might be dead forever.

Clearly, though, it wasn't. In the years that followed Intel went through a period of stagnation, while Arm chips became yet faster and more energy-efficient, making them impossible to ignore. In 2019 Microsoft unveiled a new sort of Windows device dubbed the Surface Pro X. Rather than serving as a lightweight cousin to the Surface Pro, as the original Surface had, the Pro X was positioned as a slick and stylish new alternative, with a sexy name and a full-sized screen. It featured a new Arm-based Microsoft SQ1 processor inside, developed in partnership with Arm veterans Qualcomm.

RUNNING WINDOWS ON ARM PROCESSORS ISN'T A NEW IDEA. CAST YOUR MIND BACK TO 2012 AND YOU MAY RECALL A LITTLE COMPUTER CALLED THE MICROSOFT SURFACE

ABOVE The Surface Pro X gave Windows on Arm a new lease of life

Most significantly, it ran a new Arm-native build of Windows 10, known familiarly as WoA. As with Windows RT, it looked and felt almost identical to the Intel version – but for the first time in the history of Windows it included a real-time emulation layer allowing Intel apps to install and on non-native hardware.

THE LONG AND WINDING ROAD

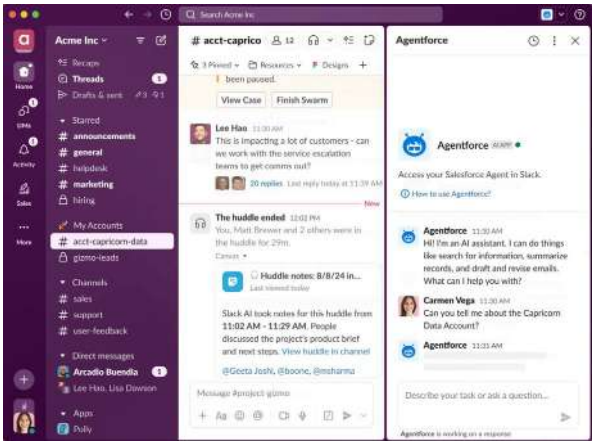
Even in the first edition of WoA, the Intel emulation layer was pretty seamless. Unlike Windows RT, the OS allowed you to freely download and install software from anywhere, with the Windows Store and other software distribution tools automatically serving up Arm packages where they were available, or falling back to Intel if they weren't. Programs compiled for Intel would automatically run in emulation mode alongside native apps, and you normally wouldn't even know it was happening: as with WoW64, the apps themselves didn't know they were running under emulation, unless they'd been specifically coded to detect it. The main thing that couldn't be emulated was low-level device drivers, so if you wanted to use weird and wonderful hardware devices, or play games designed for high-end GPUs, you'd need to use Arm-native software.

In the initial WoA release, however, there was one other limitation, and quite a significant one at that. Although the Surface Pro X system was 64-bit through and through, the bundled Intel emulator only supported 32-bit x86 apps; anything written for x64 wouldn't run.

This immediately ruled out the latest versions of many applications – after all, 64-bit Windows was at this point 14 years old. It also meant that, although the Surface Pro X came with 8GB of RAM as standard, no more than half of this was accessible to any given x86 app. Even if an x86 app would run, emulated performance could be laggy: the emulator was a work in progress and, unlike Apple's M-series processors, the SQ1 chip lacked any sort of custom silicon designed to speed up the translation from one ISA to another (it was basically a lightly tweaked version of Qualcomm's general-purpose Snapdragon 8cx).

Thankfully, only early adopters using Windows 10 on Arm had to struggle with these issues. Windows 11 was developed from the outset as a dual-platform OS, and the Arm edition introduced an emulation layer that's fully compatible with 64-bit code, along with a new hybrid emulation model – a framework called Arm64EC ("emulation compatible"), which lets programs use a mixture of native Arm code and x64 components. This means developers can build mostly Arm-native programs that only use emulation for OS components that aren't directly supported on Arm, allowing for easy performance gains without requiring deep refactoring. If you're curious as to which mode a program is running in you can open up the Task Manager and check the "Architecture"

BELOW Microsoft's latest emulator is smarter and faster than ever

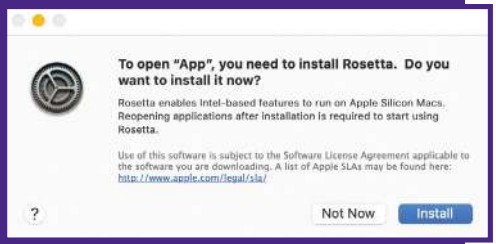


ABOVE Apps such as Affinity Photo, Slack and Zoom are available for WoA

HOW APPLE BRIDGED THE GAP

It's almost impossible to talk about platform emulation without talking about Apple, a company that has used emulator technology not once but three times in its history to pull off major platform moves. The most recent, of course, was with the launch of its own-brand M-series processors, based on a licensed implementation of the Arm architecture. The new design offered better performance and power consumption than the Intel chips the company had previously been using – but since the Intel architecture had been the status quo for the previous 15 years, when the M1 came along in 2020 it was incompatible with almost every Mac application in existence.

Apple's solution was to create a new emulation framework built into the Arm-based version of macOS, which enabled existing apps to run on the new hardware by dynamically translating Intel code into Arm-compatible instructions and calls. Strictly speaking this is an optional component of the OS, which is downloaded the first time you run an Intel application, but we doubt there are many Macs out there that don't have it installed.



ABOVE Apple's proprietary emulation system runs Intel apps at near-native speed

The decision to use emulation wasn't exactly a shock: Apple had previously made a similar move back in 1994, when it chose to migrate away from the Motorola 68000 architecture that had powered the first generation of Macintosh computers, switching to the newer PowerPC platform developed in partnership with IBM and Motorola. A decade later, Apple switched again, from PowerPC to Intel – and again provided an emulation component called Rosetta, in honour of which the current emulation framework for Arm is often referred to as Rosetta 2 (although Apple itself just calls it Rosetta).

The clever thing about Rosetta 2 is that it's not purely a software solution. As well as using clever code-translation routines, Apple has taken advantage of the fact it creates its own chip designs, to build in custom hardware that replicates the way Intel processors handle memory access. This slashes the amount of data reordering that needs to be done in software, so legacy apps generally feel as smooth and responsive under emulation as they did on native Intel silicon.

Now in 2025, though, the significance of Rosetta 2 is dwindling. Since Apple no longer sells Intel Macs in any form, almost every modern application is now Arm-native, and it's rumoured that Apple will stop supporting Rosetta 2 next year.

column: this will show "x86" for emulated code, "ARM64" for native processes or "ARM64 (x64 compatible)" for Arm64EC.

GETTING BETTER ALL THE TIME

As well as a new emulation platform, Windows 11 has seen an explosion of hardware options, with the first wave of Copilot+ PCs offering a choice of Arm-based Windows laptops from both Microsoft and third-party manufacturers, all based on Qualcomm's Snapdragon X chips. But if you're still dubious about buying an Arm-based Windows laptop, be reassured that you might rarely even need emulation. Almost all the biggest apps are available for Arm: Qualcomm's website namechecks native WoA packages including Adobe Photoshop, Affinity Photo, CapCut, Cubase, DaVinci Resolve, Dropbox, Slack, Zoom, most major browsers and a wide range of security and VPN software (see **tinyurl.com/365armapps**). A Microsoft survey found that more than 90% of "total app minutes" on an Arm-based Copilot+ PC were spent using Arm-native software.

And things continue to improve. While no official partnership has been announced, it's notable that from the original Surface Pro X to the latest Copilot+ PCs, every WoA device has used a Qualcomm processor, and it's understood that Qualcomm has been closely involved in the development of the emulation layer. That means it's being developed by those best placed to understand the chip architecture, and to continue to optimise translation as far as is possible.

As part of that optimisation, the Windows 11 24H2 update for Arm processors introduced a new version of Prism, its emulation layer. As well as supporting the basic Intel instruction set, Prism now emulates several optional x64 CPU extensions including AVX2, BMI and FMA, which can greatly accelerate specific types of data operations while reducing energy consumption by using dedicated hardware. Microsoft's support pages on emulation also tantalisingly note that "some performance features within Prism require hardware features only available in the Snapdragon X series". In other words, WoA is starting to benefit from hardware optimisations, similar to those found on Apple's M-series chips.

There's one big difference, though: while Apple has historically used emulation to smooth over a wholesale switch from one platform to another, there's no suggestion that Microsoft is planning to ditch Intel support. Rather, the expectation is that Windows will continue to support both x64 and Arm platforms indefinitely – so when choosing your next laptop, you'll be able to pick the model that best suits your needs, without having to worry about what sort of processor it has inside.

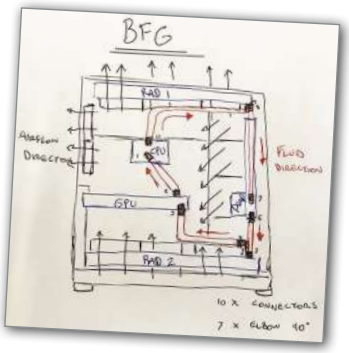
HOW WIRED2FIRE BUILT THE WORLD'S FASTEST DESKTOP PC

ONE OF THE UK'S MOST TRUSTED PC MAKERS WANTED TO BUILD SOMETHING SPECIAL FOR ITS 20TH BIRTHDAY. HERE'S THE STORY BEHIND THE BFG, THE WORLD'S FASTEST DESKTOP PC

To mark 20 years of building custom PCs, Wired2Fire decided to build the world's fastest PC. And that's the story we tell here.

"We built it as a showcase for people who want a nice PC to go with their Bugatti or helicopter," said Peter George, Wired2Fire's co-founder, his tongue firmly in cheek. "But we have sold real PCs with a similar spec to games developers."

Here, we hand over to the experts behind the BFG for their description. And no, Roald Dahl estate, the name has nothing to do with the Big Friendly Giant and everything to do with the iconic weapon from *Doom*.



LEFT **Making plans: how the BFG's design took shape**

CPU

AMD has dominated the high-performance PC space for more than half a decade thanks to its Threadripper range. Its latest flagship, the Ryzen Threadripper Pro 7995WX, was the natural choice for the BFG, featuring a gargantuan 96 cores and 192 threads. Each of these cores can boost up to a maximum of 5.1GHz, with AMD's Precision Boost Overdrive technology allowing for even higher clocks with sufficient cooling.

ABOVE **Speed up: AMD's Ryzen Threadripper Pro 7995WX**

MOTHERBOARD

Wired2Fire uses Asus motherboards in its high-end PCs and workstations due to the quality and consistency of its products for decades. For the BFG, we chose the manufacturer's top-shelf Pro WS WRX90E-Sage SE – a socket TR5 monster with eight memory slots, seven PCIe 5 slots, dual 10GbE ports and built-in overclocking support. It looks incredible, too!

MEMORY

If Asus is the king of motherboard makers then Kingston is surely emperor of the memory manufacturers, with a dizzying array of qualified memory solutions for almost any conceivable PC. The BFG is not just any PC, though, and its very particular demands could only be met by a kit with the right balance of speed and capacity: the Kingston Fury Renegade Pro DDR5 RDIMM 256GB kit. Not only does this support AMD EXPO memory mode, and a jaw-dropping speed of 6,000MT/sec, it also supports the processor's native octo-channel memory mode – that's right, the BFG has EIGHT channels of DDR5 memory.

GPU

The Nvidia RTX 4090 is the most powerful GPU ever constructed. With its jaw-dropping 16,384 CUDA cores and 24GB of ultra-fast GDDR6X memory, even the mighty RTX 6000 Ada can't dethrone it when it comes to raw content creation or gaming workloads. For the BFG, we chose the Asus ROG Strix RTX 4090 OC Edition. This mighty card is factory-overclocked and features beefed-up power delivery circuitry to maintain stability under load.

RIGHT **The Phanteks water-cooling system keeps everything chilled, even with such powerful components**

STORAGE

SSDs with a PCIe Gen 5 interface are the fastest on the planet right now, and Crucial's T705 is the quickest of them all. But we deemed even its insane 14GB/sec performance inadequate for the BFG, so we striped three together in a RAID0 configuration. This enabled a frankly ridiculous peak write speed of 24GB/sec in our benchmarks. To put the storage system into perspective, a really fast PCIe Gen 4 SSD, the flagship just a few months ago, delivers a paltry 7GB/sec.

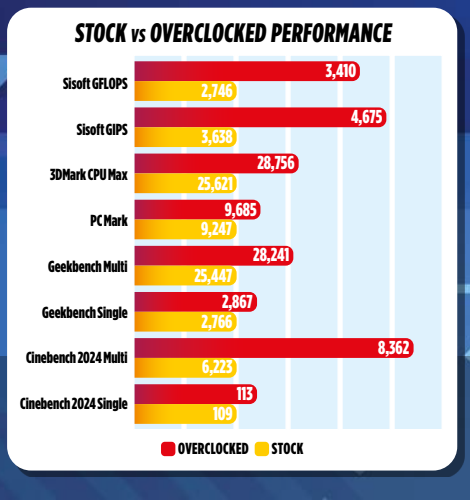
POWER SUPPLY

It was vital to us that the BFG be a usable system; therefore, a single PSU must power it. Multi-PSU systems are notoriously problematic and can also overwhelm standard domestic power sockets. We ultimately chose the Phanteks Revolt 1600W PSU – an 80 Plus Titanium certified unit. Phanteks doesn't provide cables as standard, allowing the user to choose what colours they want. We chose black for this unit as we wanted the water cooling to take centre stage.

CASE

Considering the hardware inside, the BFG is housed within a relatively compact chassis. No "supertower" requiring a two-man lift in sight. The Phanteks NV7 is nevertheless a full-tower case, and perhaps the smallest case on the market that will accommodate the incredibly large Asus WRX90 SSI EEB-sized motherboard. Despite this, it still has ample space for the system's dual 360mm radiators and houses 12 (!) low-noise 120mm fans. So not only does this system break benchmarks, it's quiet too.

THE BFG IS AN EFFECTIVE SHOWCASE DEMONSTRATING THE KIND OF PCs OUR TALENTED ENGINEERS CAN BUILD



COOLING

The water-cooling system keeping the BFG tamed is nothing short of a masterpiece, with lovingly hand-bent acrylic tubing and top-quality CPU and GPU blocks from Phanteks . We've also gone to Phanteks for the pump/reservoir unit, which takes centre stage at the front of the machine. With two ultra-thick radiators, the water cooling loop is more than up to the task of keeping the mammoth CPU and GPU tamed, even with the substantial overclocking we have performed.

ABOVE Wired2Fire's BFG, in all its dazzling, superpowered glory

BUILDING THE BFG

Hard line water cooling is a meticulous process, as the tolerances are incredibly fine. The old adage "measure twice, cut once" definitely applies here. Once the water-cooling pipes have all been cut and measured we pressure-test the loop. If it passes, you can be confident the machine won't leak once filled. With the loop filled with our signature Fire Orange coolant, we then extensively bleed the loop by running the pump overnight, periodically removing air bubbles by strategically rocking the machine back and forth. With the loop finally complete and filled, we test the CPU and GPU under load, ensuring the CPU cores are all well within their tolerances and that the GPU is free of thermal hotspots. We can finally declare the beast complete!

TWEAKING PART 1: CPU

Now begins the painstaking process of optimising and overclocking the Threadripper CPU. AMD introduced its curve optimiser feature as part of its Precision Boost Overdrive 2 (PBO2) suite. This allows granular control over the voltage applied to individual CPU cores, enabling fine-tuning of the performance and efficiency of each. We started with a negative curve optimiser per core of -15 and then tested each one, further reducing the input on stable cores and increasing it on less stable cores. This ultimately feeds the less performant cores with more juice, making them more stable at the cost of extra heat. Running a multicore workload like Cinebench resulted in all 96 cores sitting consistently at 4.8 to 4.9GHz, an insane result.

As you can see from the graphs above, we ended up with performance that was anywhere from a modest 5% in lightly threaded workloads such as Geekbench single core, all the way up to an astonishing 34% boost on rendering with Cinebench. But running an overclocked profile doubles the power consumption compared to the same chip at its default settings, so we deliver the BFG with multiple BIOS profiles, allowing you to run at stock for everyday usage, and a supercharged OC profile for when you need to bring the big guns out.

ABOVE MSI's Afterburner was used to tweak the RTX 4090

TWEAKING PART 2: GPU

We use MSI's quintessential tweaking software when optimising the BFG: Afterburner. Arguably, overclocking the RTX 4090 is like drawing a beard on the Mona Lisa, but given we have gone to all the trouble of removing the stock cooler and fitting a water block, it would be a shame to not see what the RG Strix OC can do!

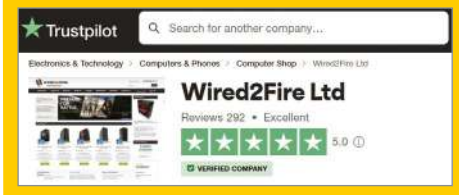
First, we unlocked voltage control and forced constant voltage to keep the card's boosting behaviour at its most consistent. We then boosted the default card voltage from the default 0.95V to 1.1V. When overclocking a video card we like to find out what the peak GPU and memory clock speed are without artefacts, then combine the two and dial it back. We ended up with +165MHz on the GPU frequency and +1,450MHz on the VRAM.

WANT TO BUILD YOUR OWN BFG?

The BFG is an effective showcase demonstrating the kind of PCs our talented engineers can build. If you want a BFG of your own, you can buy this very PC at **wired2fire.co.uk/product/bfg**. If you would prefer to build your own dream PC, then please reach out to us, and we can work collaboratively to build your ultimate PC from scratch. Want a more gaming-oriented build? No problem at all. Want a sleeper build without the fancy lights and coloured coolant? That's fine! Rest assured our team can help you build your own ultimate PC today!

About Wired2Fire

Wired2Fire is a British PC maker established in 2004. Based in Dorking, Surrey, it's committed to delivering not only fantastic custom PCs but satisfied customers – as shown by its 5-star rating on TrustPilot.



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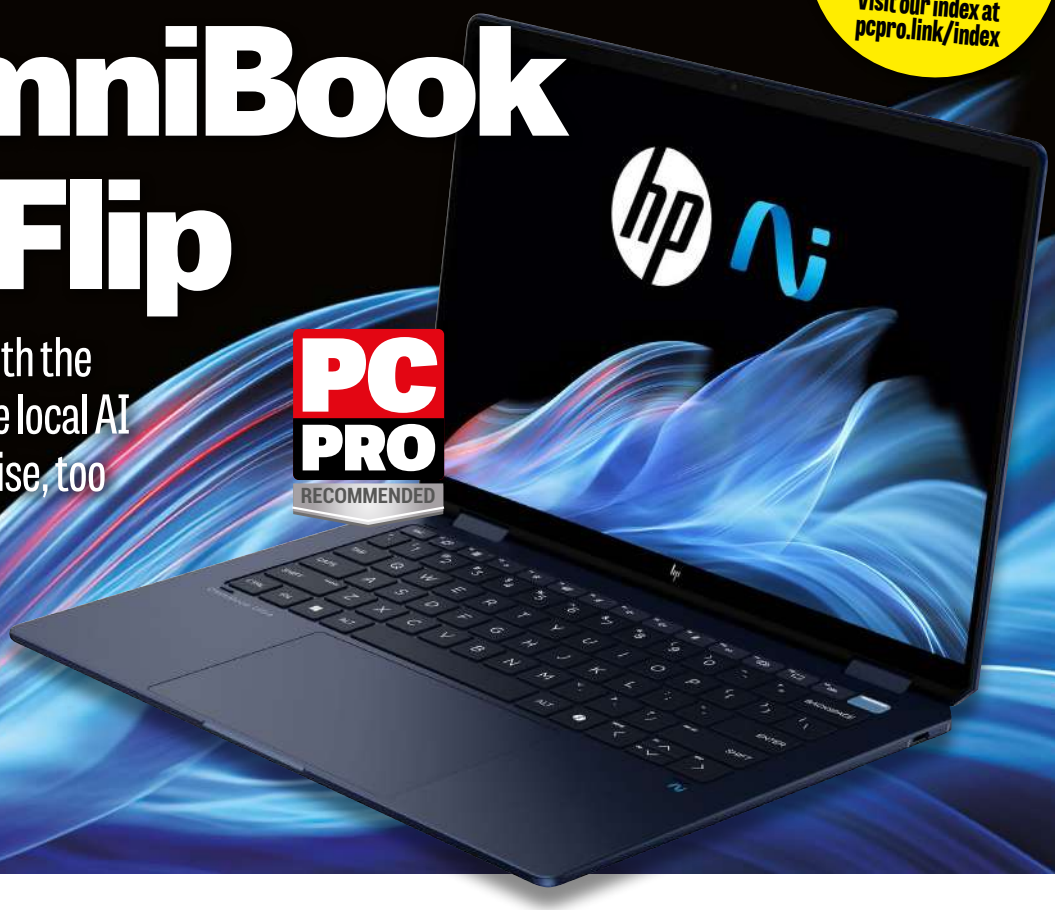
HP OmniBook Ultra Flip

A stylish 2-in-1 packed with the latest technology, and the local AI tool shows signs of promise, too

PC PRO RECOMMENDED



SCORE ✪✪✪✪✪

PRICE As reviewed, £1,416 (£1,699 inc VAT) from hp.com

Name a famous HP laptop brand. Tricky, isn't it? Dell has its XPS range, Lenovo the ThinkPad and Apple the MacBook Pro, but most people would struggle to name an HP laptop brand that exudes the same high-end class. The Pavilion is a solid budget range and I've seen plenty of attractive mid-range HP Envy laptops, but HP's top-end Spectre range never landed a killer punch.

And now it never will, for the OmniBook Ultra is here to replace it. But where the Spectre was pitched as a luxury consumer brand, the OmniBook Ultra takes aim at professional users. HP's OmniBook Ultra Flip is leading the charge, with a fresh design, striking angled corners (carried across from the Spectre family) and all the AI trimmings.

Every HP OmniBook will support Microsoft's Copilot+ PC update as they will include a CPU with a sufficiently powerful NPU. HP isn't fussed which one: the rather boring OmniBook X (*see issue 362, p54*) uses a Qualcomm Snapdragon SoC, the non-flipping OmniBook Ultra – not yet tested – a Ryzen AI 300 series, and this Ultra Flip one of Intel's Core Ultra 200V series.

Ultra difference

This makes the Ultra Flip only the third laptop I've tested to include a processor from Intel's Core Ultra 200V family; the Dell XPS 13 (*see p51*), which landed on my desk two weeks earlier, was the second, while Asus' excellent Zenbook S 14 (*see issue 362, p46*) was the first.

I tested an Ultra Flip with a Core Ultra 7 256V inside, which is identical to the Core Ultra 7 258V in the Dell XPS 13. The only reason that they have a different model number is memory support, with the 256V maxing out at 16GB and the 258V at 32GB. The Asus Zenbook S 14 I tested packed a Core Ultra 9 288V chip with 32GB of RAM.

You can see how each chip compares in the graphs opposite. Although the Core 9 Ultra has a respectable lead on its siblings, they all live in the same ballpark. If I didn't have benchmarks to separate them, I doubt I could tell the difference in real-world use. That isn't surprising, as they share the same eight cores (and eight threads, as the Core Ultra 200V doesn't support Hyper-Threading) and an identical Arc 140V graphics chip.

ABOVE HP's new laptop brand is aimed at professional users

In the world of integrated graphics, the Arc 140V is an excellent 3D accelerator. It's the first I've seen to break the 4,000 mark in 3DMark Time Spy, which brings light gaming and acceleration in supported apps (including daVinci Resolve, which we cover on p36). This doesn't mean the OmniBook Ultra Flip is the right choice for gamers, with 27fps at 1200p High in *Dirt 5* and 37fps in *Shadow of the Tomb Raider* at 1080p High, but expect a solid 15% improvement over previous generations.

> "The first real reason to choose the OmniBook Ultra over laptops based on first-gen Core Ultra chips is battery life"

Battery boost

The first real reason to choose the OmniBook Ultra over laptops based on first-gen Core Ultra chips (such as the Ultra 7 155H) or older Core CPUs is battery life. By fundamentally

changing its architecture, it has massively closed the gap with chips based on Arm technology. These still hold the advantage, but what's most crucial to laptop buyers is that you can expect a full day of battery life without needing to find a power source.

I put this to the test by taking the Ultra Flip with me when I visited IBM's European research centre (*see p14*), and deliberately keeping it switched on during the day's sessions. By the time I reached six hours of continuous use it hadn't even hit 50%. I simply didn't worry about charging it.

Obviously, what you do will have a big impact. Play games and the battery gauge drops more quickly (100% to 87% after quarter an hour of playing *Dirt 5*), while streaming Netflix video saw it seep away at a steady 7% per hour. In PCMark's Modern Office benchmark, which puts the laptop to light use in videoconferencing and office apps, it lasted 14hrs 17mins.

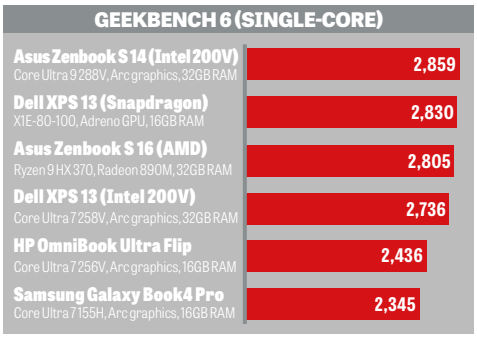
To put this into perspective, the Dell XPS 13 lasted for 13hrs 55mins and the Asus Zenbook S 14 an incredible 19hrs 6mins. And I've seen up to 24 hours from Windows laptops powered by a Qualcomm Elite chip. So, in comparison, the OmniBook Ultra Flip isn't anything special. However, I come back to my key point – that it can last a full day per charge. Which is fortunate, as HP still provides a slim but annoying "rat and tail" charger, which takes up space in a bag. The good news: when I did charge it, it went from zero to 80% in an hour.

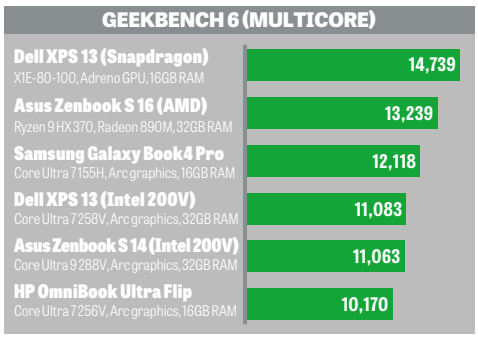
Brilliant display

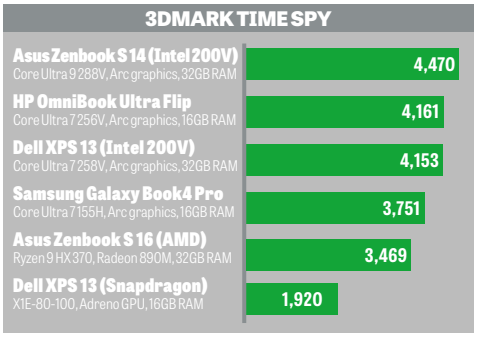
I performed all my battery tests with the screen set to 150cd/m², which can seem dark on a laptop with an IPS display. Here, though, HP wisely includes an OLED panel, and that means it's more than bright enough at this setting. Other panels go brighter – the HP peaked at 373cd/m² compared to 472cd/m² for the XPS 13 – but you'll rarely find yourself wanting more. The only potential irritant is the glossy finish, as despite the anti-reflective coating you will see overhead lights and it's not great in the sun.

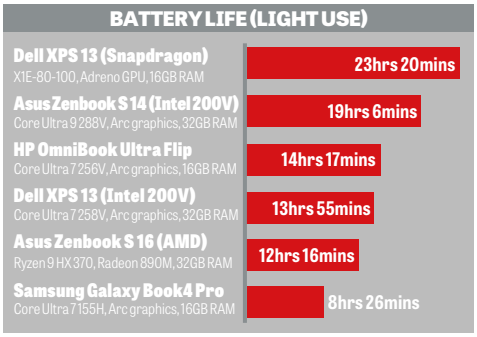
I recommend you head into the display settings and experiment with the different colour profiles. There are eight to choose from, including Entertainment, Low Blue Light, Photos and Videos (basically DCI-P3), Web (sRGB) and even Printing and Imaging. The latter locks it to an Adobe RGB profile: I measured 91% out of a 95% volume, which is an excellent figure. There's no Pantone certification, however, so if you need guaranteed accuracy then you're better off with a true creative workstation such as Asus' ProArt PX13 (*see issue 361, p50*).

If you prefer the sRGB space, this setting again does a great job, locking the panel to 100% out of a 103% volume, so you can trust what you see on screen. Add superb whites and an average Delta E of 0.39, with a peak of 0.86, and I can find nothing to fault about the panel's colour coverage.









Tablet talent

It's a touchscreen, and HP supplies its MPP2.0 Tilt Pen for onscreen drawing. This locks magnetically and securely to the right-hand side of the chassis, but sadly there's no wireless charging mechanism: sliding the end reveals a USB-C charging port. The pen and panel together support 4,096 pressure levels, but graphic designers won't get too excited: there's a slight lag when you draw on the screen, so it's better suited to signing documents, doodles and annotations than artistic work.

"Add superb whites and an average Delta E of 0.39, and I can find nothing to fault about the panel's colour coverage"

Twist the laptop round and this is a respectable makeshift Windows tablet, however. I say makeshift for two reasons: the 16:10 aspect ratio makes sense for laptops, but 10:16 is narrow when you're using it as a tablet in portrait view. For perspective, an A4 page is roughly 10:14. The second reason is simply because Windows remains a dreadful platform for tablet-friendly apps compared to Android or iPadOS.

Many Windows convertibles also suffer due to weight, but at 1.3kg I found the OmniBook Ultra Flip comfortable to hold in one hand. That's twice the weight of the 12.9in iPad Pro, but if it means you only need to carry one device on your travels then you may accept the compromise.

Laptop strength

It's as a laptop that this machine excels, helped by a superb keyboard. Start typing and you're rewarded with a firm press against a backplate that doesn't buckle, while the main keys are well delineated, large and easy to hit. And unlike Dell's XPS 13, HP provides a proper row of function keys, including a mic mute button with a tiny orange indicator light. I would have liked a double-height Enter key and properly separated cursor keys without function doubling, but these are quibbles.

HP follows the trend of haptic touchpads, but its execution is so good that I double-checked the specs to make sure. For example, I found it just as easy to drag and drop using this

BELOW The Ultra Flip can be used in tent mode, and comes with HP's own stylus

pad as I did a normal touchpad, while the XPS 13 often "dropped" my left-click. This is a big touchpad, too, measuring 138 x 86mm. So large that I wondered if I could use the stylus on it to turn the touchpad into a mini graphics tablet, but I was out of luck.

There's no room for USB-A ports. Instead, you must make do with three USB-C connectors. Two of these sit on corners that have been cut into the chassis at 45° angles to the side and rear. The left one supports USB-C 3.2 Gen 2, so 10Gbits/sec transfers, but head to the right-hand side if you want USB 4 and Thunderbolt 4 speeds (40Gbits/sec). There's a mirror to the left-hand port, cut into the corner, plus a second USB-C/Thunderbolt port. Aside from a 3.5mm jack on the left, that's it – unless you count Wi-Fi 7 and Bluetooth 5.4.

Poly more us

HP includes one more feature to attract modern workers, and that's a high-end webcam system. Badged Poly Camera Pro, this incorporates a 9MP webcam, two tweeters, two woofers and a pair of top-mounted microphones. It's worth firing up the Poly Camera Pro app, as this gives you control over the image used in your videoconferencing app of choice (it supports Teams, Zoom and web-native apps such as Google Meet). For example, you can create tiles with your name and contact details, flip the view from mirrored to normal (or even upside down) and choose whether to stream at 2K, 1080p or lower.

After all this I expected Oscar-winning video quality, but the results are strong rather than exceptional. You'll look and sound professional on calls – the microphones are excellent – but the setup is still no match for a dedicated 4K webcam.

The speakers fall into a similar category. Music is bearable, but the treble is so dominant that it can drown out vocals – for example, in "Englishman in New York" the saxophone tramples all over Sting and the other instruments.

Final thoughts

There's a huge amount to like about the HP OmniBook Flip Ultra. One of which is that it simply looks good, especially in its blue finish. With sleek dimensions and a compact metal chassis built to high standards, there's no doubt that you're buying a premium laptop.

HP also throws more than a bone in the direction of sustainability. It meets the EPEAT Gold standard, with 85% recycled metal and 50% PCR plastics used in the keycaps, bezel and speaker enclosures. If you have a Torx screwdriver you can replace the SSD and battery, while HP's usual superb documentation gives professional repairers all the information needed to replace hard-to-repair components such as the display and touchpad.

Where things become more confused is who HP expects to buy this laptop. It isn't part of HP's Elite range, aimed at larger businesses, but it's clearly targeted at professionals. You also get a consumer version of its Wolf security product, which here means "a hardened HP BIOS with HP Sure Start and Endpoint Security Controller" rather than the full suite of security and management tools.

"Anyone looking to buy a premium business laptop should consider the OmniBook Ultra Flip. I'd opt for the top-end model"

Despite this, anyone looking to buy a premium business laptop should consider the OmniBook Ultra Flip. I'd opt for the top-end model with a Core 7 Ultra 258V processor, 32GB of RAM and a 2TB SSD, which brings the price to £1,899 inc VAT. Also consider adding HP's three-year Care Pack, which guarantees pickup, repair and return of your system within seven working days for £129. While it's not a business laptop in name, it certainly is by nature – and may just be the breakthrough laptop that HP has been waiting for. **TIM DANTON**

BELOW The slim chassis has no room for USB-A ports

SPECIFICATIONS

8-core Intel Core Ultra 7 processor 256V • Intel Arc 140V graphics • 16GB LPDDR5X-8533 RAM • 14in 120Hz OLED touchscreen, 2,880 x 1,800 resolution • 1TB M.2 PCI-E Gen4 SSD • Wi-Fi 7 • Bluetooth 5.4 • 9MP IR webcam • 2 x Thunderbolt 4/USB-C 4 • 64Wh battery • HP Tilt Pen • Windows 11 Home • 314 x 216 x 14.8mm (WDH) • 1.3kg • 1yr RTB warranty • part code 14-fh0005na

HP AI COMPANION APP LEADS THE WAY FOR LOCAL AI... OR DOES IT?

One of the defining characteristics of HP's new OmniBook range is that it includes an NPU powerful enough to support Microsoft's Copilot+ PCs initiative. And HP doesn't care whether that's AMD's Ryzen AI, Intel's AI Boost or the NPU built into Qualcomm's Snapdragon X range: it simply needs to meet the 40 TOPS threshold set by Microsoft.

On top of Microsoft's own tools – Recall, Paint's Cocreator, Live Captions and Windows Studio Effects in video calls – HP is shipping its own AI Companion. Anyone can download this app from the Windows Store, but it will only work on HP laptops that include an NPU meeting the 40 TOPS threshold (I tried running it on the Dell XPS 13 overleaf, but no dice).

HP's pithy description is that it's "your own personal assistant on your PC that learns and grows with AI". It splits into three main categories: Discover, where you ask questions exactly as you might ChatGPT or Copilot; Perform, which is essentially a troubleshooter for your HP laptop – ask it a question and it should provide advice. It can also take direct control; for example, you can tell it to mute your microphone.

And then there's Analyze. Here, the idea is that you can upload your own files – currently restricted to PDFs, Word or PowerPoint docs and text files – and it will create a library that you can interrogate. For example, let's say you've been sent a presentation and a Word doc detailing a product your company is launching. Upload them to the AI Companion and it will create a library that you can interrogate. Ask it to suggest a short presentation about the new product and it won't create the document, but it will break it down into slide titles with bullet points. Of course, you can do all of this online, but HP's promise is that the library is kept locally so there's no chance of leaks.

There are smoke and mirrors here, though. I checked NPU usage in Task Manager, and it wasn't touched during the creation of the library or when I was querying it. Instead, the main work is done in the cloud. The libraries may be local, but the AI analysis is happening who knows where.

Right now, the results are distinctly mixed, too. I've seen excellent results where it created genuinely useful insights, but the AI is prone to hallucinations. Just as ChatGPT-4o is. So while I welcome the AI Companion, don't expect miracles.

RIGHT HP's AI Companion app is a promising start, but its accuracy can be questionable

How we test

Laptops and PCs

We run a selection of benchmarks on all the PCs and laptops we test. Where possible, we use a cross-platform test so we can compare Windows and macOS machines, which is where both Geekbench and Cinebench come into play. Both push the CPU to its limit, exposing how well cooled a system is.

We run extra tests for Windows systems. We use PCMark 10 to benchmark systems in office tasks, content creation and basic tasks such as web browsing and video calls. We also run 3DMark Time Spy and *Shadow of the Tomb Raider* as a minimum. We test laptops and PCs that include discrete graphics with a range of games, such as *Metro Exodus Enhanced* and *Dirt 5*.

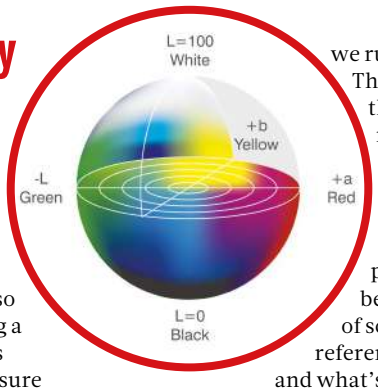
For laptops, we test battery life with Wi-Fi on and the screen brightness set to 150cd/m². We fully charge the laptops and drain them until they reach 5%. For Windows laptops, we will use a mix of PCMark 10's light-use and video-based tests, or a web surfing benchmark where a laptop automatically visits sites until the battery dies. We also use this test for MacBooks.

ABOVE We put PCs and laptops through our intensive set of benchmarks

Screen quality

In each laptop, phone, tablet and monitor review, you'll see our conclusions about the screen quality. Some of this will be subjective, but we also test each screen using a X-Rite Display i1 Plus colorimeter. We measure maximum brightness, colour accuracy and (for monitors) consistency – there may be a difference in, say, brightness from the middle and the edges of the panel.

We also measure Delta E, which is a guide to how accurately panels display colours. Anything under 1 is excellent and likely to be difficult for the human eye to distinguish; between one and two is still strong; above this suggests a panel that you shouldn't trust for colour-accurate photo editing.



LEFT We use a Display i1 colorimeter to measure sRGB gamut coverage and Delta E

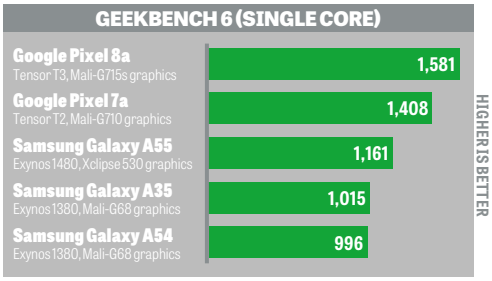
Phones and tablets

We run a selection of publicly available benchmarks on all the phones and tablets we review. First, we run Geekbench 6. This is a good test of the processor and memory in particular, and include both a test for single-core and multicore performance. See below for a selection of scores to provide a reference of what's good... and what's not so good.

We also run 3DMark Wild Life test to give a measure of gaming performance.

We test tablet battery life by playing a full-screen video until the battery runs out with the device. To simplify the test, we use Airplane mode. We set the brightness to as close to 150cd/m² as we can get in the device's settings. We also put phones through a set of real-world and labs-based tests.

BELOW We play a video with the screen set to 150cd/m² to test battery life



What our awards mean

Recommended
This, quite simply, is a product we recommend you buy – if it meets your needs.

A-List
The best buy in its category right now. The product will also feature on our A-List, starting on p14. It's updated each month.

Labs Winner
Each month we run a group test, or Labs. This product has managed to beat all others to top position.

Tinyurl.com links

Throughout the magazine you'll see tinyurl.com shortcuts. Enter these into the address bar of your browser and it will take you to a particular page, which will either be too long or awkward for us to publish or will take you to the precise shop from which to buy. If it's Amazon, note that we may have an affiliate deal in place so we will receive a commission from each sale. This will never affect our verdict of a product, and if another reputable vendor is selling the product cheaper then we will use that instead.

Prices will vary

Prices we publish are correct on the day we publish, but we often see prices change, especially on sites such as Amazon. However, we do work with British PC retailers to ensure the prices we quote for their systems are correct. If the price isn't being honoured, contact us via letters@pcpro.co.uk.

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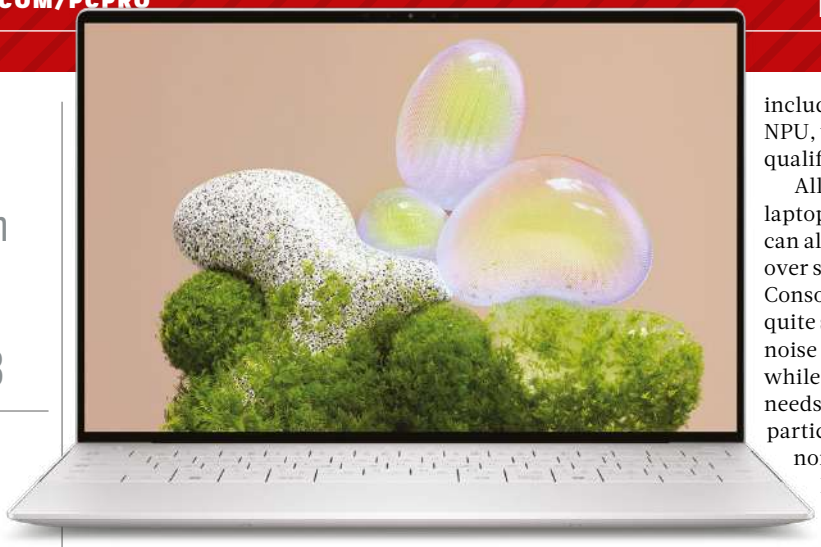
Dell XPS 13 (Core Ultra 200V)

Intel's second-generation Core Ultra 200V chips prove an excellent fit for the ultra-compact XPS 13

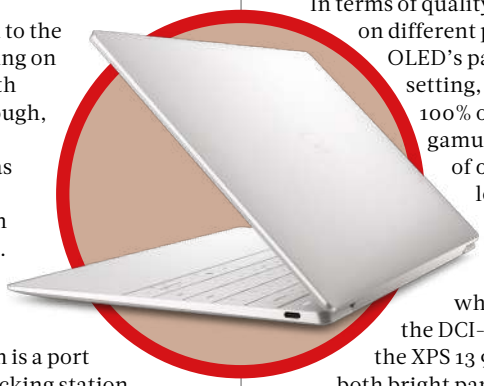
SCORE ★★★★☆

PRICE As reviewed, £1,645 (£1,974 inc VAT) from dell.co.uk



I admit to a senior moment when I unpacked the latest Dell XPS 13. Didn't we meet a few months ago, I muttered? Kind of, the laptop replied, but that was with a Qualcomm Snapdragon X inside (*see issue 361, p58*); this time I'm packing a sweet Core Ultra 7 258V, part of the 200V series that you praised for its balance of speed and battery life (*see issue 362, p46*). We stopped talking after that, as things were getting weird.

The laptops – identified on Dell's website as XPS 13 9345 for a Snapdragon and XPS 13 9350 with a Core Ultra chip – are physically identical, down to the USB-C port sitting on either edge. With Intel inside, though, they support Thunderbolt 4 as well as USB 4, giving a fraction more flexibility. If you miss having a USB-A port your best option is a port replicator or docking station.



The compensation for the lack of ports comes in the design. It isn't the lightest 13.4in laptop at 1.2kg, but with a 14.8mm height and 199 x 295mm footprint – less than this magazine – it will squeeze into the tightest of spaces.

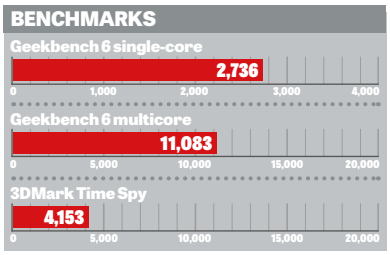
But will you need to bring your power supply? Anecdotally, no. I thrust this laptop into my bag for two trips into London and it lasted all day without being plugged in. I had around 40% left after a seven-hour day on one occasion, 50% after six hours. This was with the usual mix of office work, video calls and occasional breaks. However, if battery life is your only concern, the Snapdragon version is a better choice as shown by PCMark's light-use office test: the Core Ultra lasted 13hrs 55mins, the Snapdragon 23hrs 20mins.

There's one other big difference between the two. The Intel machine has a lovely OLED panel, while the Snapdragon-powered XPS 13 used a lacklustre but low-power IPS panel.

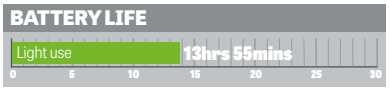
In terms of quality, the two live on different planets. At the OLED's panel default setting, it covered 100% of the DCI-P3 gamut with a Delta E of 0.57. Whites look perfect, too. That compares to off-kilter whites and 69% of the DCI-P3 gamut for the XPS 13 9345. They're both bright panels, but OLED is easier to read in all conditions due to its perfect contrast – and you can get away with lower brightness if you need to eke out battery life.

So let's call that one-all at half-time. Now we come to performance, where the Snapdragon scores excellent results in the multicore section of Geekbench 6 and Cinebench 2024: 14,739 and 958 compared to 11,083 and 577 for the Core Ultra system. But things aren't that simple, as any app that takes advantage of the GPU will find far more power in Intel's offering. That's reflected in its 4,153 in 3DMark Time Spy, twice that of the Snapdragon chip, and the point is hammered home by 44fps in *Shadow of the Tomb Raider* at 1080p and Low settings; its sibling returned 26fps. Both chips include a similarly powerful NPU, which means they qualify as Copilot+ PCs.

BENCHMARKS



BATTERY LIFE



All Dell's new XPS 13 laptops run quietly, and you can always prioritise quietness over speed in the MyDell Console. However, it takes quite some effort to hear much noise from the 9345 system, while Intel's Core Ultra chip needs more cooling; games in particular force the fans into noisy action. Fortunately, Dell provides a fine pair of speakers, with enough depth to bring vigour to films and music. The webcam and microphones are equally strong, making this a fine choice for hybrid workers, though you should probably choose Windows 11 Pro rather than the supplied Home. And you might want to upgrade the warranty from a single year of ProSupport (which includes next-business-day on-site repairs after remote diagnosis). This isn't a laptop designed for end users to replace items, but if you do fight past the tiny Torx screws the only "easy" upgrades are the M.2 2280 SSD (a speedy unit hitting 5,027MB/sec reading pace) and battery.

ABOVE The XPS 13 with Intel inside comes with a lovely OLED screen

> **"This is an excellent laptop packed with top-quality components. Where it struggles is value for money"**

The crisp keyboard with its solid backplate is another plus, as is the double-height Enter key. Dell sticks with its light-up function row, rather than physical keys, which I'm not a fan of as you don't get any feedback as you tap. However, I'm coming round to the invisible but large haptic touchpad, which stretches from the Windows key to the left cursor.

LEFT The USB-C ports support Thunderbolt 4 as well as USB 4

Overall, this is an excellent laptop packed with top-quality components. Where it struggles is value for money, because if you want the OLED panel and Core 7 Ultra chip then you'll pay a minimum of £1,899. The £1,974 price of my system is due to 1TB of storage rather than that model's 512GB. With so much competition in this area – the £1,500 A-Listed Asus Zenbook S 14 (*see issue 362, p46*) comes to mind – that's tough to justify. **TIM DANTON**

BELOW The keyboard makes typing a speedy, comfortable experience

SPECIFICATIONS

8-core Intel Core Ultra 7 processor 258V • Intel Arc 140V graphics • 32GB LPDDR5X-8533 RAM • 13.4in 60Hz OLED touchscreen, 2,880 x 1,800 resolution • 1TB M.2 PCI-E Gen4 SSD • Wi-Fi 7 • Bluetooth 5.4 • 1080p IR webcam • 2 x Thunderbolt 4/USB-C 4 • 55Wh battery • Windows 11 Home • 295 x 199 x 14.8mm (WDH) • 1.2kg • 1yr Premium on-site warranty

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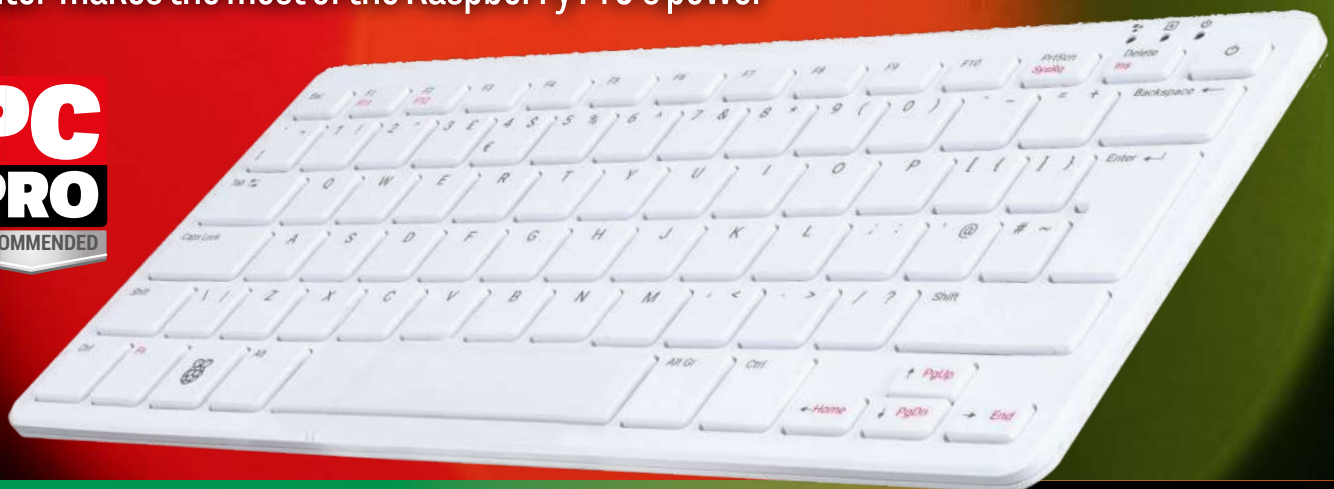
TECH, HEART & SOUL

Raspberry Pi 500

A brilliant update to the Pi 400, this "all in one" keyboard computer makes the most of the Raspberry Pi 5's power

PC PRO RECOMMENDED



SCORE ★★★★★

PRICE £71 (£85 inc VAT) from thepihut.com

When the Raspberry Pi 400 (*see issue 316, p58*) was released in 2020, it evoked nostalgia for anyone who used Commodore or Sinclair machines in the 1980s. Evidently the idea of a computer in a keyboard retains similar appeal in the 2020s, as Raspberry Pi has followed it up with the Pi 500, based on the current flagship Raspberry Pi 5.

You can buy the computer on its own for £85, or as part of the Desktop Kit for £113. Both come with a 32GB A2 SDR104-compatible microSD card, but the Desktop Kit also includes a 27W USB-C power supply, micro-HDMI-to-HDMI cable and *The Official Raspberry Pi Beginner's Guide* book.

As with the Raspberry Pi 400, all of the ports sit on the back of the case, including a single USB-A 2 port for your choice of mouse, two USB-A 3.2 Gen 1 ports and a microSD card slot (so the same as the Raspberry Pi 5). The sole USB-C input is only there to supply power, and there are also dual 4K micro-HDMI ports, a GPIO interface and a gigabit Ethernet port. Finally, there's a spot to lock your Pi 500 to a desk with a Kensington lock.

Having the ports at the back makes sense. It tidies up the cables, and means there's only need for one thick edge; the rest can be as thin as possible.

The keyboard is a membrane offering. Its chiclet keys are responsive and work well even under fast typing. It has a power button in the top right, but don't fret: it takes a long press to trigger the power-off process.

Heading inside

Held together by a series of clips, again just like the Raspberry Pi 400, the Pi 500 is relatively easy to open. Just take your time, use plastic spudgers, and carefully apply heat from a hairdryer.

Once in, I was greeted by a huge piece of aluminium covering the entire PCB and cradling the keyboard. This is the same setup as the Pi 400 and explains why the Raspberry Pi 500's thermal performance is so good. Removing the aluminium was a little tricky. The four screws were easy, but the thermal pad holding the aluminium heatsink to the SoC was stuck solid. A little heat, some plastic pry tools and patience won the battle. When putting it all back together, ensure that the heatsink is touching the thermal pad, otherwise the chip won't be cooled.

ABOVE The Raspberry Pi 500: a modern-day Commodore 64?

The PCB is very similar to the Pi 400 (a theme that permeates this review) but with the GPIO and USB ports swapped around. Looking around the board, it's hard to miss the large M.2-shaped space. A space that could accommodate up to 2280-sized NVMe SSDs, or even an AI accelerator, but there's a catch: there's no connector.

"The USB-C input is there to supply power, and there are also dual 4K micro-HDMI ports, a GPIO interface and a gigabit Ethernet port"

I asked Raspberry Pi CTO Gordon Hollingworth about this, and his response was that it was a trade off between functionality and performance versus cost. Another reason for omitting support for NVMe SSDs is that it's not exactly child's play to open the case. The plastic could be easily broken, leaving you with a cosmetically damaged Pi 500.

I also spotted an RP2-B2 chip next to the keyboard FFC connector. The RP2 is the RP2040, and the B2 stepping is the latest. This is acting as a keyboard controller, given its proximity to the keyboard FFC. Hollingworth's explanation was:

BELOW It's pretty simple to open the Pi 500, which is held together by clips

"Yes – why use a random bit of hardware when we can use our own?"

Finally, there's a large section of the PCB that's unpopulated, without a surface mount component to be seen. I spotted a place for a surface mount capacitor, but other than that, the only clue is "PoE" lettering next to a marked-out area. So evidently Power over Ethernet was another feature that didn't make the cut, for the same reason as M.2 PCI-E support.

You'll also notice that there are no connectors for the official Touch Display 2 (*see p76*) or the many Raspberry Pi cameras. The Pi 400 and 500 both lack these connectors, but you can easily connect a USB camera and two HDMI displays to the Pi 500, so it isn't a huge loss.

Thermal and power performance

Following in the footsteps of the Pi 400 is no bad thing when we're talking thermal performance. It's all thanks to that huge piece of metal that sits under the keyboard, acting as a heatsink. Passive cooling performance is remarkable, even when overclocked to 3GHz.

First up was the stock speed test. At idle, the system runs at 1.5GHz, and 31.2°C. Despite only having passive cooling, the Pi 500 remained cool even under a full five-minute stress test. Compared to the Raspberry Pi 5's idle temp of 39.5°C (passively cooled using the Active Cooler's heatsink) the Pi 500 is chilly. And it only sips 2.6W of power.

During the five-minute stress test, all four cores ran at their maximum speed of 2.4GHz and this saw the SoC hit 51°C, 8°C cooler than the Raspberry Pi 5's peak of 59°C. Power consumption under stress hit 6.4W, but that was nothing to worry about.

Buoyed by this success, I overclocked the Raspberry Pi 500 to 3GHz. I did have to adjust the voltage to keep everything stable, but once I found the magic numbers, the system performed remarkably well. The idle temperature was 33°C and using only 2.65W of power as the CPU was still idling at 1.5GHz. Running the stress test, the CPU hit 3GHz and 65°C, well under the 82°C thermal throttle point. Obviously power consumption went up, to 8.8W, but was still well within the 25W capability of the official Raspberry Pi 5 PSU.

The thermal performance of the Raspberry Pi 500 preserves the legacy of the Pi 400, and proves that with good passive cooling, the mighty BCM2712 can be tamed.

Real-world performance

With no support for SSDs, it's inevitable that aspects of the Pi 500's performance will be held back by the microSD card. Boot time is still impressive at 19.9 seconds, but that's in line with other Raspberry Pi-branded A2 microSD cards that I've tested on the Raspberry Pi 5.

Where I see the biggest difference is in read and write performance, and I'm sad to say that microSD cards are the slowest way to run a Raspberry Pi. To demonstrate this, I compared the performance of the Pi 500 to the recent Raspberry Pi Compute Module 5, which has both eMMC and NVMe storage options.

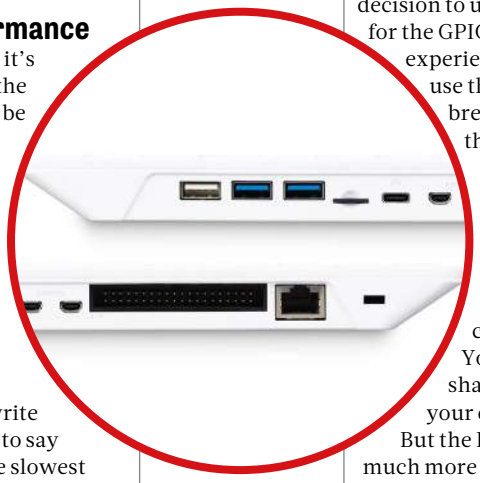
Using dd to read the entire 32GB microSD to /dev/null, I recorded the Raspberry Pi 500 reaching 89MB/sec; not a slouch, but way slower than NVMe at Gen 3 speed (768MB/sec). Sequential write speeds were recorded using Raspberry Pi Diagnostics, part of the OS. I saw 32MB/sec with the A2 class microSD, while NVMe Gen 3 reached 703MB/sec.

So does this mean that Raspberry Pi OS on the Raspberry Pi 500 is an awful experience? Not at all; I just would have preferred a faster storage option. The branded A2 class cards are excellent, and Raspberry Pi OS was snappy and responsive. I could happily use the Raspberry Pi 500 like this. But deep down I really wanted something extra under the hood.

Just like the Raspberry Pi 400, the Pi 500 needs a breakout board to access the GPIO. Luckily, the pinout is the same, so you can reuse an older breakout board. The port is covered by a rubber stopper, easily removed with a pair of tweezers. Essentially you have the same GPIO pins as the Raspberry Pi 5, and because of the changes to how Python software is installed (PEP668) and Raspberry Pi's decision to use the RP1 "Southbridge" for the GPIO, you'll have the same experience. All you need to do is use the aforementioned breakout to correctly route the pins for use with a HAT.

LEFT All the ports are at the back, but you'll need a breakout board to access the GPIO

BELOW Ports include dual 4K micro-HDMI, a GPIO interface and gigabit Ethernet



Pi 500 use cases

As with the Raspberry Pi 400, the Pi 500 is here to be a 21st century equivalent to the home computers of the 1980s. You plug in to a wedge-shaped keyboard, hook up to your display and start work.

But the Raspberry Pi 500 has much more processing power than the Pi 400, and that means it can be a viable desktop computer for those that don't need an RTX 4090 or a power-hungry CPU.

> **"The Raspberry Pi 500 has much more processing power than the Pi 400, and that means it can be a viable desktop computer"**

I do have my criticisms, most notably the lack of instant GPIO access, support for PCI-E-based storage and camera display ports, but the bottom line is that the Raspberry Pi 500 is a surprisingly powerful machine in a pleasant package. I'm old enough to remember the 1980s home computer craze, and the Pi 500 reminds me of that time, only with more power. Enough to make it a great all-rounder.

The Raspberry Pi 500 is the kit that you buy as a gift for someone who would never use a bare board, or as a child's first computer. But more than that, I can also see it being used in schools and maybe even in offices around the world. **LES POUNDER**

BELOW The PCB is very similar to the Raspberry Pi 400

SPECIFICATIONS

2.4GHz 64-bit quad-core Broadcom BCM2712 Arm SoC • 800MHz VideoCore VII GPU • 8GB LPDDR4 RAM • Wi-Fi 5 • Bluetooth 5 • 2 x USB-A 3.2 Gen 1, USB-A 2 • 1GbE • 40-pin GPIO header • 2 x micro-HDMI outputs • microSD slot • DSI display port • CSI camera port • stereo output and composite video port • USB-C (power only) • 286 x 122 x 23mm (WDH) • 1yr RTB warranty

PCSpecialist Nebula Goliath

PCSpecialist gives the best possible platform for Intel's Core Ultra desktop chips, and the result is a fine PC

SCORE ★★★★☆

PRICE £1,999 (£2,399 inc VAT) from pcspecialist.co.uk/configure-review/629/

These are challenging times for Intel, with the sudden departure of CEO Pat Gelsinger (*see p10*) and a tough debut for its Arrow Lake Core Ultra 200K series chips. These were meant to be a triumph, bringing a clever architectural design and an NPU to desktops at last, but enthusiasts weren't impressed by its focus on performance-per-watt rather than sheer performance. For the first time in recent memory, that means you can't expect a bump in speed merely because you're upgrading to the latest Intel family.

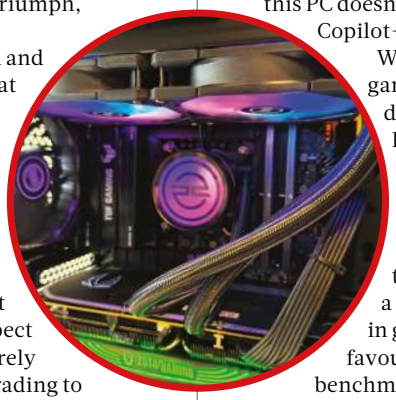
Not all these criticisms are merited. Doing the same, and sometimes more, while using less electricity is surely the right way forward. And while it may not make sense to upgrade your three-year-old Intel system – not least because you'll need a new motherboard, and even the basic ones are expensive right now – there is a better argument to buy an Intel Core Ultra PC from scratch. You're investing in a new generation of Intel systems, with room for upgrade.

Not that there will be much need to upgrade for a while. PCSpecialist opts for Intel's most powerful Core Ultra 285K processor, which features eight "Lion Cove" P-cores and 16 "Skymont" E-cores for a total of 24 cores and 32 threads. The aim is to bring raw speed when you need it and power efficiency when you don't, much like Intel's laptop chips. For the first time, it also includes an NPU – but it's Intel's first generation one, rated at 13 TOPS, so this PC doesn't meet Microsoft's Copilot+ PC criteria.

When it comes to gaming, benchmarks don't lie. An AMD Ryzen 9800X3D or Core i9-14900K system will have a slight edge, but it's incredibly rare that this edge will make a notable difference in games. If you have a favourite, check the benchmarks online, but with an RTX 4080 Super graphics card in tow the Nebula Goliath is a storming machine for 4K gaming. At Ultra/Highest settings, it returned 190fps in *Shadow of the Tomb Raider*, 142fps *Dirt 5*, 105fps in *Borderlands 3* and 69fps in *Cyberpunk 2077*. So, around 20% more than the Wired2Fire HAL 9000 (*see p59*).

It's also a great performer in demanding productivity tasks, be that video editing, software development or 3D rendering. Geekbench 6's multicore test is perfect for comparing raw CPU power, and 21,894 in the multicore test versus 16,315 for the HAL 9000 tells a clear story (although the Ryzen took the lead in the single-core test). Or consider Cinebench 2024, an incredibly tough rendering test, where the Nebula Goliath produced 2,265 in the multicore test and 138 for single-core tasks. That compares to 1,203 and 134 for the Ryzen 7900X-powered HAL 9000.

ABOVE The Nebula Goliath packs Intel's most powerful Core Ultra 285K processor



LEFT An RTX 4080 Super graphics card provides plenty of gaming oomph

It's tricky to spot the power efficiency of the new Intel chip in a PC with an RTX 4080 Super inside, as even when doing nothing this demands watts. Given this, it's impressive to see the Goliath idling away at 60W and peaking at 541W – both lower figures than the Wired2Fire PC. Note that PCSpecialist can use an 850W power supply while its rival chose an 950W unit.

That's despite the fact this is a larger system with much more expandability thanks to the top-end Asus TUF Gaming Z890-Plus WiFi motherboard. This offers four DIMM sockets (two of which are free), one PCI-E 4.0 x4 slot and two available PCI-E 4.0 x1 slots, plus three unfilled M.2 sockets. The one that's full packs a fast 2TB SolidIGM SSD that returned 7,149MB/sec sequential reads and 6,577MB/sec writes. There's plenty of space inside the large but classy Fractal Design Focus 2 chassis for adding more storage, too.

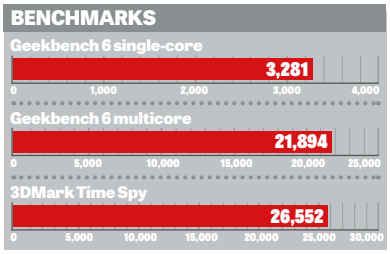
In fact, "classy" is a great word to describe this PC as a whole. Despite its thunderous power, it runs quietly – there's a low hum at idle, mainly due to the liquid cooling system, but it isn't distracting, and while the fans inevitably ramp up to meet demanding situations it's never an inferno of noise. And for those who want to overclock, the Asus motherboard has all the software tools you need, along with support for Wi-Fi 7 and a 2.5GbE port.

> **"Backed up with *PC Pro*-award-winning customer service and reliability and Intel couldn't have asked for a better debut"**

Back this up with *PC Pro*-award-winning customer service and reliability and Intel couldn't have asked for a better debut. You're paying for all this quality, but you could argue that the jump in speed is worth the £500 over the Wired2Fire system, for example. My only caveat is that we expect to see new Nvidia cards shortly, so if gaming is your priority it's worth delaying your purchase until we see exactly how fast these are. **TIM DANTON**

BELOW There's lots of space inside the large but classy Fractal Design Focus 2 chassis

BENCHMARKS



SPECIFICATIONS

24-core Intel Core Ultra 285K processor • Asus TUF Gaming Z890 Plus WiFi motherboard • 32GB Corsair Vengeance DDR5-6000 RAM • 16GB Zotac GeForce RTX 4080 Super Trinity graphics • PCS FrostFlow 240 Series Liquid Cooler • 2TB SolidIGM P44 Pro PCI-E Gen 4 SSD • Wi-Fi 7 • Bluetooth 5.4 • Fractal Design Focus 2 chassis • 850W Corsair RMx Series Plus Gold PSU • Windows 11 Home • 215 x 472 x 451mm (WDH) • 3yr warranty (6 months C&R plus 6 months RTB parts & labour, 2yr RTB labour only) • power: 60W idle, 541W peak

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pro-series

mid [PRO1]

£449.99

CPU	AMD RYZEN 5 8500G
Core	6 Cores - 12 Threads
Clock	(3.5/5Ghz Turbo)
Mob	ASUS TUF A620M-PLUS WIFI
RAM	ADATA 16GB DDR5 5600Mhz
M.2	TRANSCEND 1TB M.2 nVME
GPU	AMD RADEON Graphics
Case	KOLINK Observatory HF MESH
O/S	*NO OPERATING SYSTEM*
PSU	BUILDER 500W PSU

Max [PRO2]

£979.99

CPU	AMD RYZEN 5 7600X
Core	6 Cores - 12 Threads
Clock	(4.7/5.3Ghz Turbo)
Mob	ASUS PRIME B650M-A WIFI II
RAM	ADATA 32GB DDR5 5600Mhz
M.2	TRANSCEND 1TB M.2 nVME
GPU	NVIDIA RTX4060 TI 16GB
Case	1stPlayer D3-A aRGB - Black
O/S	*NO OPERATING SYSTEM*
PSU	CIT 700W PSU

UBER [PRO3]

£1159.99

CPU	INTEL Core i5 14600K
Core	14 Cores - 20 Threads
Clock	(2.6/5.3Ghz Turbo)
Mob	ASUS B760M-K
RAM	ADATA 32GB DDR5 5600Mhz
M.2	ADATA 2TB S70 Blade M.2 nVME
GPU	NVIDIA RTX4060 TI 16GB
Case	GAMEMAX F15M MESH
O/S	*NO OPERATING SYSTEM*
PSU	BEQUIET 850W Gold PSU

Aurora RANGE

i3 Aurora [AUR1]

£629.99

CPU	INTEL Core i3 14100F
Core	4 Cores - 8 Threads
Clock	(3.5/4.7GHz)
Mob	ASUS B760M-K
RAM	ADATA 16GB DDR5 5600Mhz
M.2	TRANSCEND 1TB M.2 nVME
GPU	NVIDIA RTX3050 8GB
Case	GAMEMAX Abyss Mini RGB
O/S	MICROSOFT Windows 10/11
PSU	CIT 600W Bronze PSU

i5 Aurora [AUR2]

£999.99

CPU	INTEL i5 14400F
Core	10 Cores - 16 Threads
Clock	(Turbo 4.7Ghz)
Mob	ASUS B760M-K
RAM	CORSAIR 32GB DDR5 6000Mhz
M.2	ADATA 2TB M.2 NVMe
GPU	NVIDIA RTX4060 8GB
Case	CORSAIR iCUE 4000X
O/S	MICROSOFT Windows 10/11
PSU	CORSAIR 650W PSU

i7 Aurora [AUR3]

£1599.99

CPU	INTEL Core i7 14700KF
Core	20 Cores - 28 Threads
Clock	(3.4/5.6Ghz Turbo)
Mob	ASUS PRIME Z790-P WIFI - DDR5
RAM	CORSAIR 32GB DDR5 6000Mhz
M.2	ADATA 1TB S70 Blade M.2 nVME
GPU	NVIDIA RTX4070 12GB
Case	CORSAIR iCUE 4000X RGB
O/S	MICROSOFT Windows 10/11
PSU	CORSAIR 650W Gold PSU

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Wired2Fire HAL 9000 Compact PC

Don't be fooled by its size; this is a powerhouse for gaming and all-round tasks – and it runs quietly, too

SCORE ★★★★★

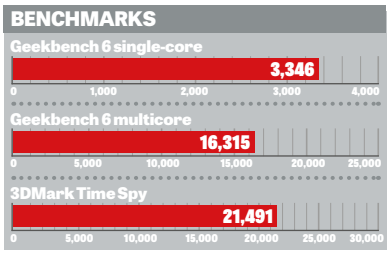
PRICE £1,583 (£1,900 inc VAT)
from wired2fire.co.uk

The Wired2Fire HAL 9000 follows a pattern of compact gaming/creative PCs to land at *PC Pro* recently, including the PCSpecialist Torpedo R (*see issue 363, p56*) and HP Omen 35L (*see issue 364, p60*). They cost a similar amount to the HAL 9000, too, at £1,799 and £1,800 respectively. But where the Torpedo and Omen included RTX 4070 Super graphics, Wired2Fire ups the ampage with an RTX 4070 Ti while making the package smaller: its total volume is 18.25L compared to 25L for the Torpedo and 35L for the Omen.

The Cooler Master NR2300P Max V2 chassis is finished in an anodised grey that looks much better in the flesh than it does in photos, and sits squat on a desk with a 185 x 295mm footprint. Measuring 377mm high, you could even pop it onto a shelf; the front-mounted USB ports, (two USB-A and one USB-C) sit neatly next to the power switch and 3.5mm audio jack at the front. Most of the time this PC runs near silently, with the fans disturbing the peace only when I pushed the CPU in benchmarks or the GPU in games.

The chassis includes a choice of side panels: one tempered glass, the other a decorative selection of holes backed by mesh that offers a glimpse of what's inside. In this case, that means you'll see the pair of glowing RGB DIMMs – a 32GB G.Skill Trident Z5 Neo DDR5-6000 kit – and that's it, with Wired2Fire focusing on performance rather than bling. A huge Palit Super Infinity 3 OC graphics card dominates the innards, but look closely and you'll find Cooler Master's 280mm liquid cooler and powerful 850W Gold PSU sitting behind.

BENCHMARKS



ABOVE The HAL 9000 packs an awful lot of power inside its diminutive chassis

What you can't see is the incredibly fast 2TB Kingston Fury Renegade SSD – 7,375MB/sec and 6,985MB/sec sequential reads and writes respectively – which fills one of the two M.2 slots on the MSI B650I Edge WiFi board. To access the empty M.2 slot you'll need to remove the graphics card, and there are two mounting positions for 2.5in SSDs as well. But it will be tight.

The final core component is AMD's Ryzen 9700X processor, and it's a superb choice for this system as it provides plenty of single-core power for games that need it – you don't want the CPU to hold the RTX 4070 Ti back – while its eight powerful Zen 5 cores mean that it also excels in tasks that will take advantage. We saw this in the multicore sections of Geekbench 6 and Cinebench 2024, where it stormed to 16,315 and 1,203 respectively. It's also the first system I've tested to break the 10,000 barrier in PCMark 10, with a 10,220 return.

It isn't too shabby at playing games either. Sure, the PCSpecialist Nebula Goliath (*see p56*) has the advantage thanks to its RTX 4080 Super card, but that PC also costs £500 more. The HAL 9000 is a strong 4K gaming choice, with averages of 161fps in *Shadow of the Tomb Raider*, 118fps in *Dirt 5*, 87fps in *Borderlands 3* and 57fps in *Cyberpunk 2077*. Those were all at Ultra or Highest settings; dropping to High increased those results to 180fps, 136fps, 97fps and 96fps. Collectively, those results are between 10% and 20% more than the PCSpecialist and HP systems that are the HAL 9000's natural rivals.

BELOW The backplate leaves precious little room for ports

PC PRO RECOMMENDED

"This is the best compact gaming PC we've seen, and naturally those skills will extend to creative applications as well"

The only downside to the Wired2Fire's figures are its power demands, with 62W at idle and a peak of 746W. You can switch to a more conservative BIOS profile, however, and I only saw that peak when I simultaneously ran 3DMark and Cinebench. In games, it typically demanded around 400W.

Before you decide whether to buy the HAL 9000, make sure that you can cope with the relatively few upgrade options. There are no spare PCI Express slots, and the backplate leaves little room for ports: five USB-A (three of which offer 10Gbits/sec), one USB-C 3.2 Gen 2x2 (20Gbits/sec), three audio outputs and a 2.5GbE Ethernet port are your lot. At least wireless connectivity is covered by an integrated Wi-Fi 6E and Bluetooth 5.3 chip, with a pair of aerial connectors on the rear.

You're well covered when it comes to the warranty, too, with five years in total. The first two years are collect and return cover that includes parts and labour, with the remaining three years being labour-only where you will need to pay courier costs. Wired2Fire also promises lifetime telephone support. And while we didn't get enough feedback in our annual reliability and service survey to rate Wired2Fire's support, we're reassured to see a five-star verdict on TrustPilot.

All of which means this is the best compact gaming PC we've seen, and naturally those skills extend to creative applications as well; switch to Nvidia's Studio drivers and expect superb results in supported CAD and 3D design software. I can't fault the price, either, with £1,900 being more than fair for the components and build quality on offer. The quiet running – most of the time – is the final bonus, making this an easy PC to recommend. **TIM DANTON**

SPECIFICATIONS

8-core AMD Ryzen 7 9700X processor • MSI B650I Edge WiFi motherboard • 32GB G.Skill Trident Z5 Neo DDR5-6000 RAM • 16GB Palit RTX 4070 Ti Super Infinity 3 OC graphics • Cooler Master MasterLiquid 280mm AIO Water Cooler • 2TB Kingston Fury Renegade PCI-E Gen 4 SSD • Wi-Fi 6E • Bluetooth 5.3 • Cooler Master MasterBox NR200P V2 chassis • 950W Cooler Master V SFX Gold PSU • Windows 11 Home • 185 x 295 x 377mm (WDH) • 5yr warranty (2yr C&R, 3yr RTB labour only) • power: 62W idle, 746W peak

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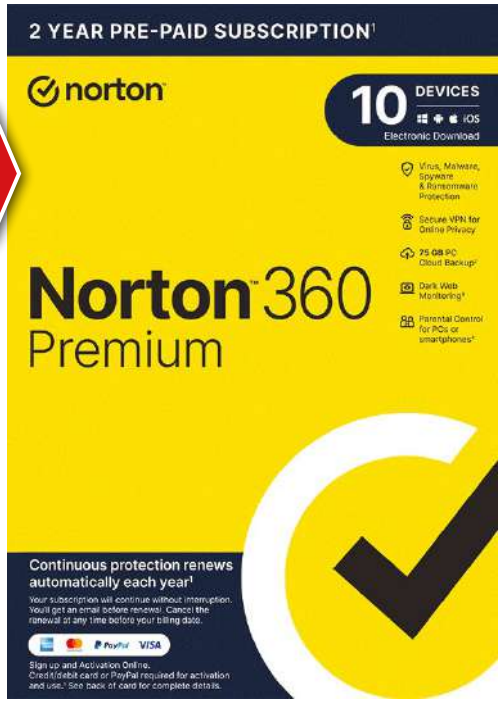
To round things off, Norton Password Manager generates and stores passwords across all your devices, while SafeCam for PC stops cybercriminals attempting to take photos with your webcam without your knowledge.



NORTON UTILITIES ULTIMATE 2025 for £14.99

10 DEVICES | 1YR LICENCE

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Norton is as famous for its PC optimisation tools and as it is its security suite, and we've negotiated 50% off the price for a ten-device, one-year licence.

For people who don't want to get too involved, there are various one-click options to reap quick results. But you can also take things slowly, working through all of the recommendations the software offers after analysing your computer.

The Dashboard gives a handy overview of your system, complete with the breakdown of various issues that have been detected. This can range from problems in the Registry, junk files wasting space or unnecessary startup programs increasing boot times and slowing down your computer.

Then there's Norton Utilities' Toolbox, which includes numerous cleanup and optimisation tools – again, these can be used in automatic or manual mode. Tools include all-in-one cleanup, internet cleanup, Windows cleanup, Registry cleanup and an advanced uninstaller.

Head to the Speed up section and you'll find a memory optimiser, startup time reducer and defragmenter. Or use the Real-Time Boost, which uses a series of algorithms to optimise power usage, boost CPU speed and free up memory. Protect is home to various privacy-related tools such as a secure file shredder, while Recover helps fix problems with your computer.

Rather than include a single licence, the £14.99 price covers ten computers.

ACRONIS TRUE IMAGE 2025 ADVANCED for £29.99

1 PC OR MAC | 1YR LICENCE

tinyurl.com/trueimage2025

Acronis provides a one-stop security shop here, combining a full backup suite with comprehensive anti-malware protection.

It offers the full gamut of backup options, from individual files to complete drive imaging (with smart incremental and differential options to encourage daily backups without filling your storage), active disk cloning for migrating to faster or bigger hard drives, and support for cloud-hosted backups to give you access to your files from anywhere on any device.

There's also an Archive option for offloading larger files to the cloud, a Sync tool that works with two PCs with Acronis installed, and a host of additional disk-related tools, including system clean-up and drive-scrubbing tools, Acronis Secure Zone (an encrypted partition for storing sensitive files) and Acronis Universal Restore (a tool for migrating all your apps, documents and settings to a new PC).

Acronis True Image is simple to use, with a user-friendly front end that's packed with lots of wizards and step-by-step guides. And there's plenty of advanced tuning available to those who want full control over their system.

The Advanced package improves on Essentials by offering you 50GB of cloud storage. You can still back up to local disks, network attached storage or remote destinations via FTP. You can also back up Microsoft 365 data and setup automatic replication.

Eizo FlexScan EV3450XC

A slick curved monitor that comes with all the docking features you need, but wait for the price to drop

SCORE ★★★★☆

PRICE £888 (£1,036 inc VAT)
from photospecialist.co.uk

Eizo's FlexScan EV3450XC is here to solve a problem. If your workspace is cluttered with a webcam, speakers and cables, it can swoop in and replace them all. Along with an RJ45 port, you'll benefit from a 5MP webcam that supports Windows Hello for automatic logins, while the USB-C port delivers up to 94W of power – enough to juice up even the most demanding laptops.

And why put up with two 24in or 27in monitors when a curved 34.1in monitor delivers 3,440 x 1,440 pixels? That's more than enough to display two or even three windows next to each other, and thanks to a Picture by Picture option you can view two outputs at the same time. There's a generous dollop of inputs, too, with two HDMI ports and a DisplayPort sitting next to the USB-C connector.

Eizo has clearly put thought into the design, with a sleek, stylish look and a choice of white or black finishes. The sturdy stand offers 195mm of smooth height adjustment, so you'll have no problem finding the right position, and there's further good news for IT admins: remote management is possible via its InStyle Server software. Then there's Eizo's excellent reputation for reliability, with the reassurance of a five-year warranty.

All this is reflected in the price, but the gently curved FlexScan EV3450XC will surely drop significantly from its current £1,036 listing. I expect its price to follow the same trajectory as the Labs-winning FlexScan EV3240X (*see issue 357, p91*), a 32in flat 4K monitor that cost £1,448 inc VAT at the time of review but is now £863.

So let's focus on the hardware rather than the price. Most curved monitors use MVA panels, which aren't always fantastic at showing whites. Instead Eizo has chosen an IPS panel, and as a result whites look perfect. The drawback of IPS technology is that – to use a technical term – it isn't as bendy as a 34in MVA curved monitor. You still reap the benefits, though, as the edges of the screen are a fraction closer to you than a flat monitor.

As ever, Eizo's onscreen display makes changing settings easy. Press the bezel next to the central power switch and up pop context-sensitive icons. For example, to switch between inputs, adjust the audio (the pair of powerful 4W speakers are fine for speech radio and conference calls but not balanced enough to make music a joy) or switch between colour modes.

Two modes are available to the tweakers of this world, but there's not a huge amount to play with here. You can adjust the gain for red, green and blue, change the gamma (1.8 to 2.4 in 0.2 increments) and switch between colour temperature presets from 4000K to 10000K, but the EV3450XC isn't designed for creative users.

Most will be better off choosing from the preset colour options: sRGB, Paper, Movie and DICOM. I stayed in sRGB mode in day-to-day use, which locks to 93% of that space without overspill. With an average Delta E of 0.62 you can be confident of the colours you're seeing, even if they lack the impact of wider gamut panels. The Paper option is great for relieving pressure on your eyes while reading long documents – it's a sepia-like mode – while Movie maximises the colours. At most, you can see 79% of the DCI-P3 space.

You can also switch between settings using Eizo's Screen InStyle software, but for this you must be connected via USB-C or USB-B. The latter brings the two USB-A ports and a USB-C 3.2 Gen 1 port into play; these all sit conveniently on the left-hand side of the screen.

Power demands range from 13W at its lowest brightness setting (a barely credible 0.5cd/m²), 30W at 200cd/m² and 39W at its 300cd/m² peak. You can also let Eizo's EcoView detect ambient light levels and adjust the screen's brightness.

The final piece of good news is that the webcam, neatly integrated into the top of the bezel, is good enough to use for web calls. That height adjustment also comes in handy to find the right camera angle. You can select 1440p in the camera settings, but don't expect image quality to match a dedicated Logitech or Tiny webcam; low light is a challenge, with lots of noise. I also found the noise-cancelling microphones over aggressive, so suggest sticking with the mics in your laptop. But I don't want to be too critical. The webcam does the job, and it's great that it supports Windows Hello for easy logins.

Until the price drops, I wouldn't recommend anyone rushes out to buy this monitor, but if you're looking to upgrade your office workspace then get in touch with an Eizo reseller to negotiate a deal when they become more widely available. **TIM DANTON**

"Why put up with two 24in or 27in monitors when a curved 34.1in monitor delivers 3,440 x 1,440 pixels?"

ABOVE The monitor is easily big enough to view two or even three windows side by side

BELOW The sturdy stand offers plenty of height adjustment

SPECIFICATIONS

34.1in 3,440 x 1,440 IPS panel • up to 60Hz refresh rate • 6-bit + FRC (16.8 million colours) • 5ms response time • DisplayPort (HDCP 2.3/1.3) • 2 x HDMI (HDCP 2.3/1.4) • USB-C upstream (94W power delivery) • USB-B upstream • USB-C 3.2 Gen 1 downstream (15W) • 2 x USB-A 3.2 Gen 1 downstream • 1GbE RJ45 • 3.5mm headphone jack • 2 x 4W speakers • 5MP webcam • 90° swivel • -5° to 35° tilt • 195mm height adjustment • 820 x 250 x 415-610mm (WDH) • 12.1kg • 5yr warranty

Amazon Kindle Scribe (2024)

Genuinely useful AI tools make this update difficult to resist, even if the price diminishes its appeal

SCORE ★★★★☆

PRICE 16GB, £317 (£380 inc VAT) **from amazon.co.uk**

We need to address the obvious: the Amazon Kindle Scribe now costs more than an iPad. It's also almost twice the price of the original 2022 Scribe, which starts at £235. But don't turn the page on this note-taking wonder just yet, because there are genuinely strong reasons to buy it.

It's not just a little better than its predecessor, it's a whole new level of better. This is no longer a big e-reader with doodling features tucked away. This is a fully fledged writing tablet, and it does some things better than any other writing tablet I've seen.

So what has Amazon improved? Is it thinner and lighter? Nope. Bigger screen? By a decimal point. Oh, it must be in colour now? Sorry!

The improvements are all down to AI. But don't be put off by the buzzword: it's so good that I almost wish Amazon hadn't told me the Scribe uses AI. I could just think it got much better at handwriting recognition because my writing had improved. Another reason for the price hike is the Premium Pen, which features a rubbery eraser tip. In terms of replicating the feel of writing on paper, the Scribe falls somewhere between the reMarkable 2 and Koba Elipsa. So, a fine writing experience.

The 7in E Ink screen is similar to that of the Paperwhite Signature Edition opposite, but it's worth mentioning its 300ppi text. That compares to 264ppi on an iPad Pro and 226ppi on the reMarkable 2. This is also the brightest writing tablet you'll find, and the light can become warm if you want to read at night and avoid blue light.

There are a couple of neat touches that also lift the new Kindle Scribe, such as the white border around the display. The device looks more like an electronic notebook than it did before, and an incredibly slender one at that (the reMarkable 2 is 4.7mm to the Scribe's 5.7mm, but doesn't include a light). Kudos too that the old cases fit the new tablets.

But it's the software that makes the new Scribe stand out, including an elegant solution to writing in e-books. Rights issues mean you can't alter the work directly, which Kobo gets around by letting you add annotations – but when you return, you have to be in the same orientation at the same text size. Amazon instead uses a "canvas" tool concept, where the Scribe draws a box on the page in which all your writing is contained; the size of the box is dictated by how much you write. Crucially, the box stays near the point in the page where you added it. This means you can't underline words or circle terms, but it's a great compromise.

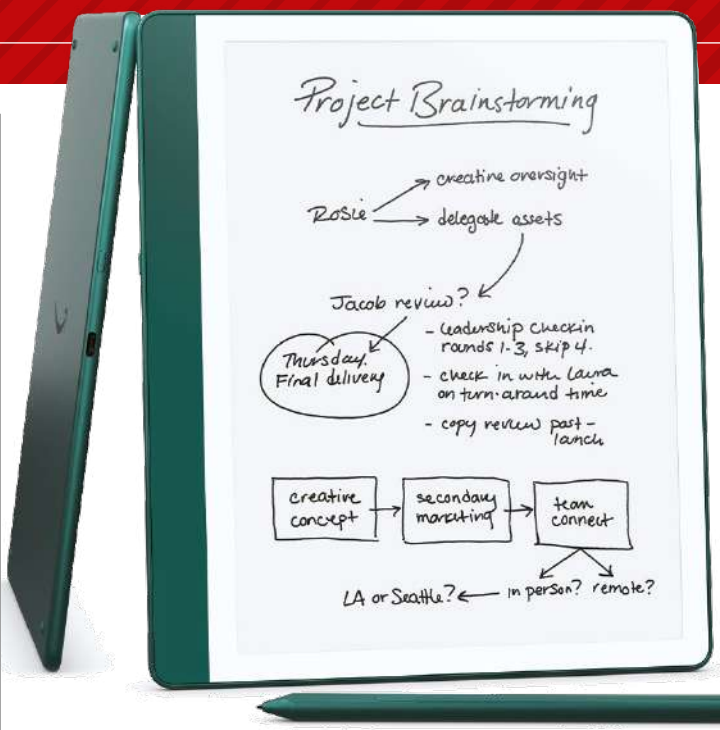
Then we come to the AI tricks. First up, handwriting recognition – Amazon calls it refining your notes – which works better than I've seen on any writing tablet before. In fact, the Scribe could read my handwriting better than I could. The second is note summaries. This automatically recognises what you've written and then creates a summary, which is perfect for meetings or classes.

The only annoyance is the delay when you activate the AI tools. The Scribe must communicate with the cloud for every request and response, and it took the Kindle Scribe up to 40 seconds to read a full page of my bad handwriting and return a typed version.

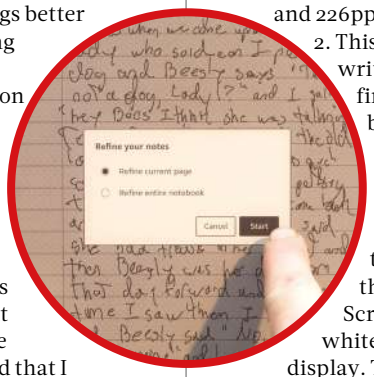
At least the AI's power demands are offloaded from the Scribe, which means you can expect nigh-on identical battery life to the Paperwhite opposite. Reading-wise, that means 12 weeks for half an hour a day. Writing-wise, it's 30 minutes per day for three weeks. Charging is slow, though, taking two-and-a-half hours to go from empty to full using the 9W charger.

So is the new Scribe worth the money, when you're basically paying for AI features and a better stylus? I have to say yes. But rather than the dull Tungsten Grey version, opt for the Jade Metallic option. It only comes with 64GB of storage, which ups the price to £430, but trust me when I say it's worth it. **PHILIP BERNE**

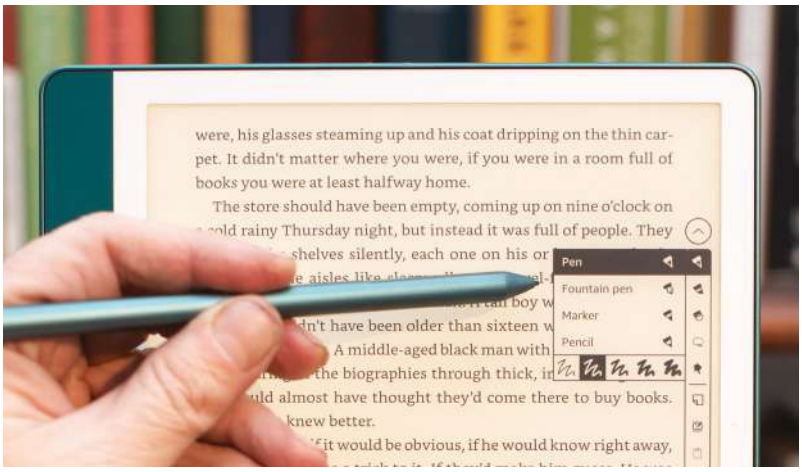
"The improvements are all down to AI. But wait: it's good! So good that I almost wish Amazon hadn't told me the Kindle Scribe uses AI"



ABOVE The new Kindle Scribe demonstrates how useful AI can be



LEFT Handwriting recognition is incredibly good



LEFT The Premium Pen replicates the feel of writing on paper pretty closely

SPECIFICATIONS

10.2in E Ink Paperwhite screen • 300ppi • 8-core 1GHz MediaTek MT8113 SoC • 1GB RAM • 16GB/32GB/64GB storage • Wi-Fi 5 • Bluetooth 5 • battery capacity not stated • USB-C connector • Kindle Premium Pen • 196 x 5.7 x 230mm (WDH) • 433g • 1yr limited warranty

Amazon Kindle Paperwhite Signature Edition (2024)

Minor upgrades add up to a big improvement, with a boost in performance and a brighter screen

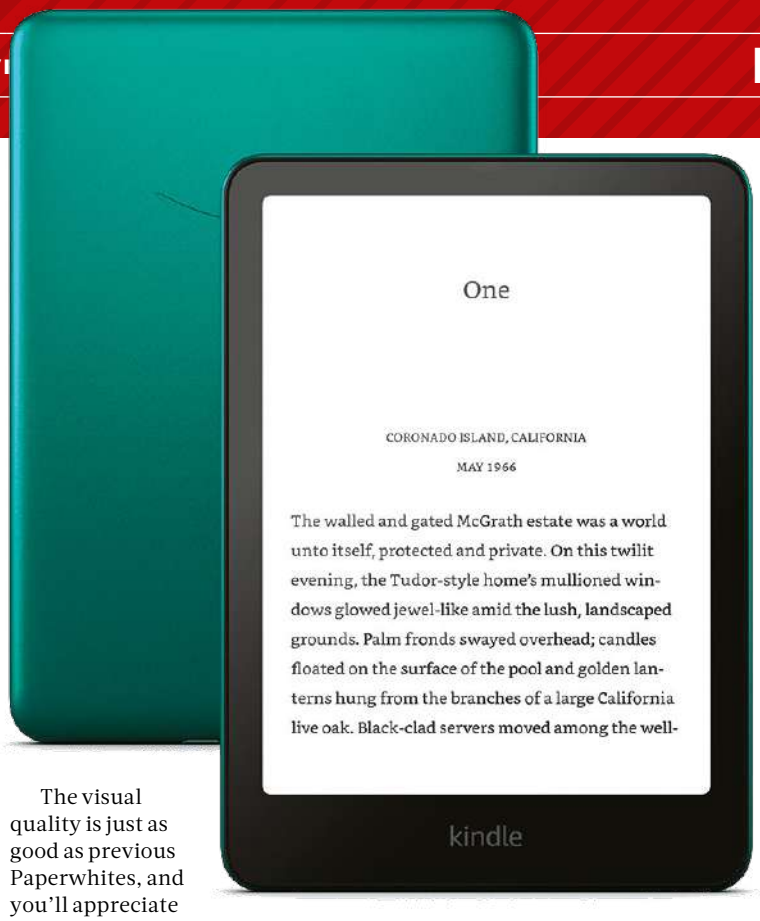
SCORE ★★★★★

PRICE £158 (£190 inc VAT)
from amazon.co.uk

The new Amazon Kindle Paperwhite Signature Edition (SE) has three clear advantages over the plain £160 Paperwhite, which has also just been updated. First, it comes with 32GB of storage rather than 16GB. Second, it supports wireless charging. And third, you aren't hit by any ads (the ad-free Paperwhite costs £170). Add an auto-adjusting front light and there really is no good reason to consider the Paperwhite, other than Amazon often slashes its price in flash sales.

You also benefit from a metallic finish to the paint, with three options available: black, green and pink. I far prefer this look to the basic matte finish you'll find on the plain Paperwhite. The downside is that it made me mourn for the Kindle Oasis, which felt truly premium with its metal chassis and real page-turn buttons. The latter are also a reason to choose a Kobo alternative as buttons remain easier than swiping or tapping on the correct spot when you want to turn a page. There's only one button on the Kindle Paperwhite SE, and it's the unfortunately placed power button. If you rest the Paperwhite on a desk while reading, you might turn off the screen by accident.

Both new Paperwhites use the latest E Ink black-and-white Carta 1300 display. This doesn't offer more sharpness than past Kindle screens, but it does increase contrast ever so slightly. That helps text stand out, making it easier to read without straining. Pictures look surprisingly good in 16 levels of grey, but if you want a Kindle with better graphics then you should consider the £270 Kindle Colorsoft.



ABOVE Text is easier to read, and a metallic finish gives the device a classy look

The visual quality is just as good as previous Paperwhites, and you'll appreciate the extra inch if you're moving up from a 6in Kindle. The front light reaches bright heights, and with an auto-adjusting light sensor it will seamlessly respond to changing conditions in your room. If you're in a well-lit room you won't need any light at all, but those who read in bed and rely on the light will appreciate the full set of amber and white LEDs that eliminate blue light.

Amazon claims that the Paperwhite SE will last for 12 weeks between charges, which assumes that you're reading at half brightness and for half an hour each day. That translates to around 40 hours of screen time, and the battery won't die if you put the book down for a couple of weeks. For a typical person reading a typical book, that means you should be able to read a couple of novels before you need to recharge the Paperwhite. That's exceptional for any modern electronic device.

And, as mentioned, the Signature Edition features wireless charging. There's no charger in the box, only a USB-C charging cable, and if you don't happen to own a charger that meets the 9W specification then Amazon will be happy to sell you one for £18. Alternatively, you can buy Amazon's wireless charging dock for £38.

These are all nice improvements over what came before, but the biggest difference you'll notice is how quickly the pages turn. That's due to a dual-core processor, which is more than powerful enough to cope with the basic interface. The display also does an impressive job of keeping up with the improved performance inside; I expected to see more ghosting and residual characters as I zoomed in and out of a page, but the new Paperwhite offers a lighter version of screens while panning, before flashing briefly and producing a darker, final version when I stopped.

The only area where the Kindle lags behind modern technology is in touch sensitivity. I still felt a delay between tapping the screen, such as when I needed to enter my Wi-Fi password, and when the character appeared. Menus were faster while I was navigating, but still not totally reliable when tapping through them.

There's little else to say about the interface (let's not call it an OS). There is a web browser, but it's so simple that it can't cope with modern sites. At least you won't be distracted and start browsing time-sapping websites on this e-reader. And, naturally, if you're looking for annotating abilities then you should consider the new Kindle Scribe opposite or the Kobo Libra Colour (*see issue 357, p70*).

So, should you buy the Paperwhite Signature Edition? If your current offering is tired, then yes. The bigger, better screen alone is reason enough to upgrade. Plus, with an IPX8 rating, it can be immersed in 2m of water for an hour; but note the lack of dust ingress resistance and Amazon's limited one-year warranty. If you aren't locked into the Kindle library of books then it's always worth investigating what Kobo has to offer – the Clara Colour is £40 cheaper than the Paperwhite Signature Edition – but if you're Amazon through and through then this is now the best Kindle out there. **PHILIP BERNE**

PC PRO RECOMMENDED

"The front light reaches bright heights, and with an auto-adjusting light sensor it will seamlessly respond to changing conditions"

LEFT There's support for wireless charging – not that you'll need to charge it very often

SPECIFICATIONS

7in E Ink 16-level greyscale touchscreen • 300ppi • 32GB storage • IPX8 • 2.4GHz/5GHz Wi-Fi • Bluetooth • USB-C connector • 128 x 7.8 x 177mm (WDH) • 214g • 1yr RTB warranty

Huawei Watch GT 5

Huawei's best mid-range offering so far thanks to accurate tracking and measurements

SCORE ★★★★☆

PRICE £191 (£230 inc VAT) from consumer.huawei.com/uk

Huawei's latest mainstream smartwatch comes in 41mm and 46mm sizes, both of which are cheaper than their counterparts from Apple, Google and Samsung. First impressions are fantastic: the stainless-steel case looks less like a modern smartwatch and more like something a stylish grandparent might have worn. On the right-hand side you'll find the crown and the secondary function button; these are set well apart from each other to avoid any accidental operation, and the angled positioning of the crown keeps it neatly out of the way.

In practice, I rarely reached for either of the physical controls: the touchscreen works so well, and the interface so intuitively designed, that they're hardly necessary. The face is a beautiful 1.43in AMOLED colour screen that's big, bright and impressively fingerprint-resistant.

I do have gripes with the design. While it's hard to make a smartwatch that's slim enough to fit discreetly on the wrist, it would have been great if Huawei had shaved a millimetre or two off the thickness. I'm also not enamoured by the strap. There are eight variants; I tried the blue fluoroelastomer band on a 46mm watch and never warmed to it. After some adjustment I had it sitting comfortably on my wrist, but the material looks and feels cheap, undermining the upmarket vibe of the body. The 41mm version offers a greater range of options, including a Milanese metal strap, which suits the classy watch much better.

RIGHT The stylish Watch GT 5 looks like a classic timepiece

In terms of software functions, the GT 5's big selling point is Huawei TruSense, a new sensor system that measures "more than 60 health and fitness indicators, covering six of the body's major systems, and also includes an emotional wellbeing component". I'm dubious about this last part: I don't mind checking in from time to time, but I can't see myself relying on a watch to monitor my emotional state.

For more traditional activity tracking, the GT 5 offers plenty of analysis, especially for runners and cyclists. As well as the usual measurements of distance, speed and so forth, runners can track time in contact with the ground, balance and vertical oscillations, while cyclists benefit from a selection of real-time data on the go. Other supported workout types include walking, swimming and skiing, with metrics tailored for each.

I tested the watch across a variety of workouts – including running, cycling, walking, hiking and playing football – and encountered no glitches or weird results. The on-watch metrics have been thoughtfully designed for the circular interface, with clean and attractive graphs and figures, so you'll have no problem keeping track of your performance.

GPS tracking worked well, mapping my running route with admirable accuracy. The watch picked up my location as soon as I stepped outside, and didn't drop out once thereafter.

As well as programmed exercises, the GT 5 can auto-detect when you're exercising. I found this hit and miss: it never thought I was exercising when I wasn't, but it didn't always pick up when I was exercising. Still, if you forget to tell it you're starting an activity, at least there's a chance the watch will start recording on its own.

For the end of an active day, the GT 5 has no shortage of sleep-monitoring tools, with trackers for your sleeping heart rate, SpO2 and respiratory rate. The watch is small and light enough not to be a bother at night (especially the 41mm version), and its collected data can be easily accessed through the Huawei Health app, available for both iOS and Android. As well as a spot analysis of your previous night's sleep, this can show long-term trend analysis and statistics based on how well you've slept.

"The face is a beautiful 1.43in AMOLED colour screen that's big, bright and impressively fingerprint-resistant"

It's all topped off with a smattering of the usual smartwatch features. Incoming messages and notifications pop up automatically on your wrist, and you can even tap out replies using a tiny onscreen keyboard. Unfortunately, the GT 5 can't display images or play voice messages, and you can't use your voice to dictate a response except with a Huawei phone.

There's one area where the Watch GT 5 indisputably wins over the big-name wearables, and that's battery life. As with the GT 4, you can expect around seven days of typical usage between charges; if you're sparing with your usage you could get as much as 14 days of use out of a full battery.

When it comes to messaging, the GT 5 isn't as slick and capable as a premium smartwatch, but if you're primarily interested in activity monitoring it's a great choice for the price. **PAUL HATTON**

ABOVE Huawei's TruSense sensor system keeps tabs on key health indicators

LEFT Activity data is presented in a clear, visually attractive way

SPECIFICATIONS

Shared: Mic and speaker • GPS • Bluetooth 5.2 • heart-rate sensor • gyroscope • geomagnetic sensor • air-pressure sensor • temperature sensor • 5ATM water resistance • IP69K • HarmonyOS • 2yr RTB warranty. **41mm:** 1.32in 466 x 466 AMOLED display • 41.3 x 9.5 x 41.3mm (WDH) • 35g. **46mm:** 1.43in 466 x 466 AMOLED display • 45.8 x 10.7 x 45.8mm (WDH) • 48g

Huawei Watch D2

Blood-pressure monitoring marks this smartwatch out from the crowd, but it's bulky as a result

SCORE ★★★★☆

PRICE £292 (£350 inc VAT)
from consumer.huawei.com/uk

Huawei introduced the concept of smartwatch blood-pressure monitoring with the Watch D back in 2022, but this was a quiet, limited release. With the D2, it's going mainstream. The idea remains the same: it delivers ambulatory blood-pressure monitoring (ABPM) through a 26.5mm airbag attached to the inside of the watch strap. This inflates quickly and easily, capturing this vital health metric whether you're working, exercising, relaxing or sleeping. You can even create a 24-hour auto-monitoring plan to check trends across day and night, but prepare to be rudely awoken.

The obvious question is how accurate it is. I ran the same tests numerous times and gained similar results, delivering results within my normal blood pressure spectrum. Extra reassurance comes from certification by the EU's Medical Device Regulation body. The only problems I hit were when it refused to take a measurement at all, but this was down to my incorrect positioning of the watch.

Huawei has improved its ECG analysis with this update, producing more accurate and responsive results. There's a huge amount of data here to identify the presence – or otherwise – of common heart conditions. Huawei's sleep mode includes heart rate, SpO2, respiratory rate and abnormal breathing tracking, giving you a detailed report in the morning through the Huawei Health App (available for Android, iOS and HarmonyOS, Huawei's phone OS).

The Watch D2 also provides white noise, natural soundscapes and relaxing music to help you sleep, while sleep tracking accurately detected all my awakenings as well as times that I was in deep or light sleep. During the day, whether I walked, ran, played football or cycled, the D2 picked up GPS without issue. Likewise all the other health metrics this watch tracks, and as ever the Health app provides a faithful companion for digging deeper into those.

Naturally, it comes with regular smartwatch features, too: notifications, the ability to make and receive calls, and you can listen to music offline. But there are significant limitations compared to Android Wear and Apple watches, including no support for contact payments, listening to music through Spotify or WhatsApp audio messages. The US ban on Android support for Huawei isn't such a limitation for watches as it is for phones, but the experience isn't as slick as rivals.

As ever, Huawei delivers the goods when it comes to hardware design. The 1.8in AMOLED display takes centre stage, providing a big screen for showcasing watch faces, health data and notifications. A resolution of 480 x 408 translates into 347ppi, and text and graphics look fantastic with a high level of definition and vibrancy.

The display is surrounded by a stylish black or gold aluminium alloy case, and exudes quality. I have no concerns about durability – although Huawei doesn't name which brand provides the screen protection – but it's always reassuring to see IP68 support and a two-year warranty.

A rotating crown and function/ECG button complete its physical attributes, and both perform well. I used the touchscreen more than the buttons, but they're handy when you want them.

The Watch D2 would benefit from a thinner bezel, especially at the top and bottom of the display. The watch is chunky with a 48 × 38mm footprint (armprint?), and it's 13.3mm at its thinnest point. That excludes the sensor area, which pushes the watch even higher on your wrist – and that's my biggest criticism of this watch, which is that it's simply too thick.

Huawei provides two watch strap options, including "Black Fluoroelastomer" and "White Composite Leather". I tested the former. The material looks great and, more importantly, feels nice on the wrist. This surprised me, as the blood-pressure monitor airbag strip is directly connected to the watch strap, and it looked uncomfortable; in practice, it simply provided an extra level of cushioning.

Huawei promises six days of battery life for the Watch D2 under normal use, and that's exactly what I found. However, I squeezed out more when I only used it for exercise tracking and basic smartwatch features, rather than regular blood-pressure monitoring. The watch ships with a wireless USB-A charger, magnetically connecting with no need for a particular orientation.

If you don't need blood-pressure monitoring there's no point buying this watch; the Huawei Watch GT 5 (*opposite*), Pixel Watch 3 (*see issue 362, p61*) or Samsung Galaxy Watch 7 are all slimmer and pack more features. Nor can I ignore the comparatively high price. But if you do want to track your blood pressure, there's simply nothing else like the Huawei Watch D2 – and you're still buying a respectable smartwatch that excels for health monitoring elsewhere.

PAUL HATTON

ABOVE Huawei's new smartwatch offers accurate health measurements

"There's a huge amount of data here to help you identify the presence – or otherwise – of common heart conditions"

LEFT The rotating crown and function/ECG button both work well

BELOW At 13.3mm thick, the Watch D2 is a chunky beast

SPECIFICATIONS

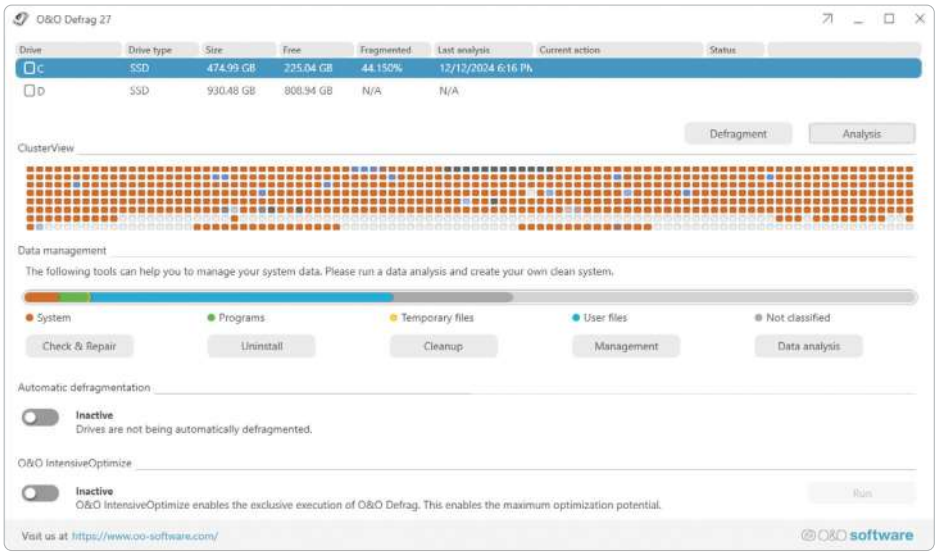
Custom chipset • 1.8in 480 x 408 AMOLED touchscreen • 32GB storage • Bluetooth 5.2 • GPS • IP68 • loudspeaker • body temperature sensor • blood-oxygen sensor • heart-rate sensor • gyroscope • barometer • differential pressure sensor • 524mAh battery • HarmonyOS • 38 x 13.3 x 48mm (WDH) • 40g • 2yr RTB warranty

Your bonus software

Total value this month £170

We scour the globe to negotiate the best software deals for our readers, from extended licences to full programs you don't need to pay a penny for. Here's this month's lineup

O&O Defrag 27 Professional



Full product worth £39
oo-software.com
REQUIRES Windows 10 or later; 120MB hard drive space; online registration

The longer you use your computer, the messier its storage drive becomes. Over time, as you write, edit, overwrite and delete files, Windows will do its best to fit new data between the blocks that already exist. It's inevitable that those blocks will get more and more scattered – or fragmented – as your computer ages. The drive will have to work harder to deliver the data you need as it skips back and forth to gather the various parts required to assemble a complete file, and inevitably this slows things down.

Before spending money on a new, faster computer, it makes sense to try tidying up. You can't do that manually, so a powerful and highly configurable hard drive defragmentation tool such as O&O Defrag is the answer.

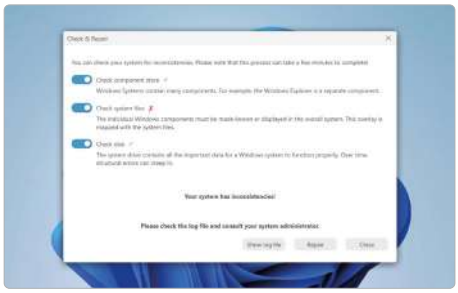
At first the program looks much like any other defrag tool. Launch it and you'll be presented with a list of your drives. Selecting one displays the usual mosaic-style map of its file layout; now click Start, and watch as O&O Defrag reorganises its contents to ensure the best possible performance.

This is just the start, though. If you have multiple drives installed in your system, you can select as many as you like and the program will defragment them all simultaneously.

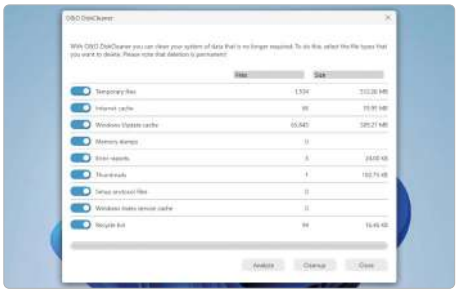
You don't have to use one defragmentation strategy, either. You can choose to have your files organised by their filename, access date, last modified date and more – whatever best suits your needs. And if none of these options suits, you can set up a custom layout scheme that optimises Windows, application files and your user data for the best possible system performance.

As well as reorganising your data, Defrag 27 Professional can check your hard drive or SSD for inconsistencies and display what it's found. If it identifies any problems, most can be repaired directly within the suite.

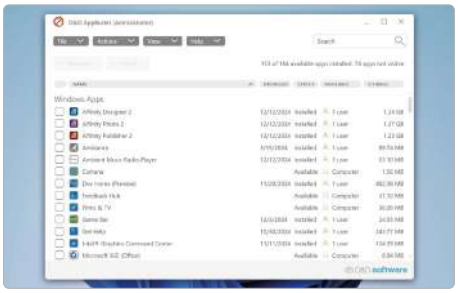
While some of this might sound complicated, none of it is overly complex. Once you've set up O&O Defrag to work as you'd like, it will mostly run in the background, defragmenting your drive automatically when required while you get on with other things. Or, for more advanced users, you can run it from the Command Prompt, to incorporate it into your own scripts. It's so light on resources and can be configured not to run at all if your system is busy or other heavy-duty programs are running, so it's most unlikely to ever get in your way.



ABOVE As well as defragmenting your drive, the suite can check for problems with your storage and, in some cases, repair issues that it finds



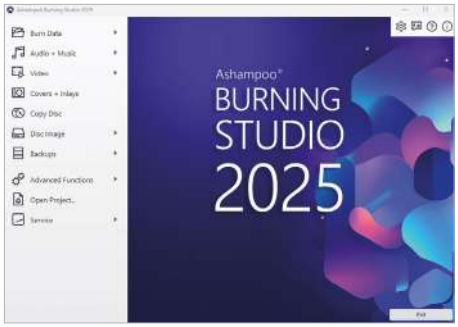
ABOVE There's no point defragmenting data that you don't require: the DiskCleaner can remove what you no longer need and reclaim the space



ABOVE Similarly, the AppBuster tool can save disk space and improve performance by removing programs that you no longer use

Ashampoo Burning Studio 2025

- Burn CDs, DVDs and Blu-ray discs with just a couple of clicks. Includes backup tool and cover designer
- Create autostart discs that display interactive menus or launch files as soon as they are inserted
- Works with a wide range of audio formats including WMA, MP3, OGG, FLAC and WAV



■ Full product worth £44 ■ ashampoo.com
REQUIRES Windows 7 or later; 200MB drive space; in-application registration

Abelssoft AntiBrowserSpy 2024

- Quickly and easily optimise the security settings for Firefox, Edge, Chrome, Safari and Opera
- Includes tools to block Google Analytics and social network plugins, plus both Flash and Silverlight cookies
- Changes your browser fingerprint over time to prevent sites from using it to track you

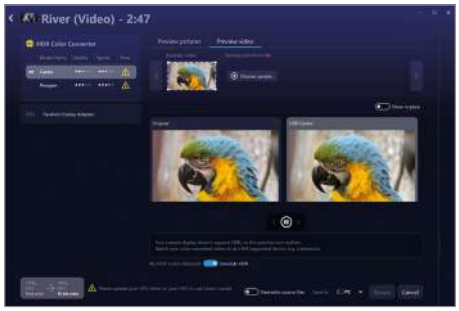
■ Full product worth £10 ■ abelssoft.com
REQUIRES Windows 7 or later; 75MB drive space; in-application registration

Ascomp Cleaning Suite 4

■ Full product worth £18 ■ ascomp.de
REQUIRES Windows 7 or later; 50MB drive space; in-application registration

- Clean up your drive, get rid of files you no longer need and reclaim lost space
- Speed up and optimise your computer with help from its uninstaller, Registry cleaner, RAM cleaner and more

Audials Vision 2025 SE



■ SE version worth £20 ■ audials.com
REQUIRES Windows 10 or later; 500MB drive space; in-application registration

- Automatically optimise your videos with help from AI for sharper, more vibrant results
- Upscale lower-resolution footage for use on 4K displays, and convert to HDR to improve colours
- Slow down footage and enhance speech

Avast Driver Updater 2024

■ One-year, single-PC licence worth £39 ■ avast.com REQUIRES Windows 7 or later; 50MB drive space; online registration

- Keep your drivers up to date to optimise performance and avoid bugs and security issues
- Identifies components and cross-references against a database of recent updates
- Save yourself the chore of multiple installations

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Xiaomi Mix Flip

Delivers for display and camera quality as well as performance, but the software offering falls behind rival flip phones

SCORE ★★★★☆

PRICE £749 (£899 inc VAT) from amazon.co.uk

While other big names have grabbed the publicity, Xiaomi has been quietly mastering the art of making foldable phones. The Mix Fold handset is in its fourth generation, and the manufacturer now debuts its first clamshell design, the Mix Flip.

With an RRP of £1,099 inc VAT it would be competitive with Samsung's Galaxy Z Flip6 (*see issue 360, p73*), but the usual flurry of cut-price deals means you can currently buy it for £899 from Amazon. And while the Motorola Razr 50 Ultra is cheaper (*see issue 360, p68*), starting at £699, the Xiaomi includes a more powerful Snapdragon 8 Gen 3 processor, not to mention a generous 512GB of storage.

Desirable design

The Mix Flip has a look all of its own, with pillowed glass and a body that – although thicker than other clamshells – still feels pleasingly slim and comfortable both in the pocket and in the hand. It's offered in black or a rather lavender-looking purple; the lightly textured glass on the back provides a classy contrast to the polished metal frame and glossy outer screen, and the hinge cleverly contains a microphone that's exposed when the phone is closed, so you can make and receive calls without unfolding the case. When you do open it up, the action is smooth but sturdy, so you can happily prop the phone up in an "L" shape or tent format – ideal for watching content without a stand, or taking snaps without a tripod.

The design does strike a few bum notes, in my view. The volume rocker is uncomfortably high up the phone's right edge when unfolded, as is the side-mounted fingerprint sensor. And while the front is protected by Xiaomi's tough Shield Glass, there's no IP certification for protection against dust and water – so handle with care.

ABOVE The Mix Fold has a look all of its own – and plenty of power within the clamshell

BELOW A microphone in the hinge lets you make calls when the phone is closed

Double display

The outer display is a striking 4in AMOLED screen that covers the full front of the phone, flowing luxuriously around the dual cameras. It looks great, and quality remains consistent when you open up the bigger 6.9in main display: both panels offer solid viewing angles with brilliant colour depth, brightness and contrast.

> **"A challenge with clamshell phones is how to fit in a decent camera array, but the Mix Flip manages better than any rival I've seen"**

A pixel density of 460ppi keeps everything perfectly sharp, and the refresh rate on both displays automatically scales from 1Hz to 120Hz to suit whatever you're doing. And it's tuned to the DCI-P3 gamut, giving noticeably punchier colours than, say, the Razr 50 Ultra.

To top it off, the phone's settings give you heaps of control over things such as colour balance, app-specific appearance and always-on display options, which make the Mix Flip a great nightstand companion.

Disappointing distro

This all runs on Xiaomi's Android-based HyperOS, which works fine but is far from my favourite spin on the platform. In some places it feels too rigid: for example, there's no quick

LEFT The striking 4in outer screen can host full apps as well as showing the time and weather

access to native Android features such as automatic brightness and extra dimming, although you can install third-party apps that resurface such controls. More egregious is the growing commercialisation of Xiaomi's own apps: the App Mall, Theme Store and Game Center all repeatedly bugged me with unwanted notifications and ads during testing, pushing me to buy assets or apps that I had no interest in.

There are plus points, too, though. The Theme Store isn't just a cash-grab – it's packed with free user-made submissions for endless and effortless personalisation. And the design team has done a great job of adapting the OS to the Mix Flip's almost square outer display, by effectively dividing it into two sections. The portion next to the cameras shows the weather, time, recent apps and so forth, while the remaining rectangular space can host full apps such as Google Maps, Instagram, Spotify, TikTok and YouTube. Since the app area is quite close to 16:9 in shape, this works very nicely – but be warned that only approved apps are allowed to appear on the outer display. You can't just throw anything on there, as you can with the Razr 50 Ultra.

The other main thing that's new in this version of HyperOS is – surprise, surprise – a set of AI features. The photo-editing tools now include AI Expand (which lets you crop outwards on a photo, generating new detail around the edges) and object removal, while elsewhere you'll find speech-to-text transcription, translation and summarising. These features don't always deliver perfect results on their first try, but no doubt this will improve over time.

Dynamite delivery

General app performance is very good, thanks to the Snapdragon 8 Gen 3 chipset and plenty of RAM. Apps spring open quickly, and split-screen or floating window multitasking is fast and fuss-free. There's plenty of storage for big downloads, too, although I wouldn't necessarily recommend the Mix Flip for gaming; while it can happily handle high-quality graphics, there's very little space inside for cooling, so after a spell of intensive gaming you're likely to see performance throttle down to prevent overheating.

Another challenge with clamshell phones is how to fit in a decent camera array, but here the Mix Flip manages better than any rival I've seen. Its main and telephoto cameras both use 50MP sensors with pixel binning to create clean 12.5MP stills – or video footage at resolutions up to 8K – and the results look great. Colour and tone are well handled, producing solid contrast without the heavy-handedness you sometimes get from the latest iPhones and Pixels. Xiaomi's long-standing partnership with Leica gives you the option to shoot in Leica Vibrant mode or authentic digital film stocks, along with a set of Leica-approved filters that can be applied at or after capture.

The trade-off is detail and sharpness, which can't quite match the crispness of "flagship" camera phones. But you can still take great shots with the Mix Flip, and the flip format means you can stand it up without a tripod, hold it half-open like an old-school camcorder or shoot full-quality selfies using the outer screen as a viewfinder.

ABOVE The flip format is brilliant for video chats, watching films and taking selfies

Direct debit?

Despite the phone's small size, Xiaomi has also managed to fit in a capacious 4,780mAh cell, yielding up to around seven hours of screen-on time – enough to get you through the day if you're not driving it too hard. Honestly I'd expected more from a battery of this size, but I guess the display setup eats a fair bit of power. Thankfully, a snappy 67W charger is included in the box, which allowed me to top up to two-thirds full in only 30 minutes, or to a full charge in under an hour. It's just a shame that there's no support for wireless charging.

It's tricky to get a flip phone right, but the Xiaomi Mix Flip nails the fundamentals. It boasts a pair of great displays, excellent app performance and cameras that are as good as you could expect. Just remember, if you're coming from a regular "candy bar" handset, that you may need to adapt to the shorter battery life, and handle the phone with more care than you're accustomed to. Be prepared, too, to spend time silencing and tweaking system features to tame the worst irritations of the software. **ALEX WALKER-TODD**

BELOW The 6.86in main display provides lots of depth, contrast and brightness

SPECIFICATIONS

8-core 3.3GHz/3.2GHz/3GHz/2.3GHz Qualcomm Snapdragon 8 Gen 3 • 12GB RAM • Adreno 750 graphics • 6.9in foldable 120Hz AMOLED screen, 1,224 x 2,912 resolution • 4in AMOLED 120Hz cover screen, 1,392 x 1,224 resolution • 512GB storage • dual 50MP/50MP rear cameras • 32MP selfie camera • 5G • Wi-Fi 7 • Bluetooth 5.4 • USB-C 2 connector • 4,780mAh battery • Android 14 with HyperOS • open, 74 x 7.6 x 168mm (WDH); closed, 74 x 16 x 74mm (WDH) • 190g • 1yr warranty

Oppo Find X8 Pro

An "ultra" phone in all but name, this is an excellent alternative to Apple's and Samsung's flagships

SCORE ★★★★☆

PRICE £874 (£1,049 inc VAT)
from oppostore.co.uk

LEFT The curved display makes the Oppo Find X8 Pro comfortable to hold

Owned by the same firm as OnePlus, Oppo isn't a huge name in the UK, but the Find X8 Pro demands attention with a big, bright display, four rear cameras, a huge battery and a surprisingly reasonable price.

That's not to say it's cheap. At £1,049 inc VAT we're in premium territory, but that includes 16GB of RAM and 512GB of storage, which is more than you'll find on rival phones in this price range. Two colour options are offered: sensible Space Black and the more characterful Pearl White, which has a unique texture on every handset.

The big camera block at the back reflects the OnePlus connection, and Oppo has also borrowed the physical alert slider from OnePlus, which is handy for quickly switching between regular, silent and vibrate-only modes.

The display is curved on all edges, making it comfortable to hold both vertically and horizontally. The 6.8in AMOLED panel is perfectly sharp at 449ppi, and Oppo claims an impressive peak brightness of up to 4,500cd/m², along with an adaptive 1-120Hz refresh rate. Toughened glass and aluminium rails ensure everything's sturdy, and an IP69 rating indicates an unusual degree of waterproofing – this isn't just a phone you can take swimming, it will survive high-pressure water jets at up to 80°C.

Another notable design feature is the touch-sensitive Quick button on the side. This works similarly to the iPhone 16's Camera Control, allowing you to open the camera, swipe to zoom and tap to fire the shutter. It's not as versatile as Apple's version, but it's arguably easier to use.

The cameras comprise a regular main shooter, an ultrawide module and two telephoto units offering 3x and 6x magnification. All have a 50MP resolution, so you can expect consistent levels of detail.

Image quality tends toward the dramatic, with dark shadows and bright highlights. The results aren't as natural as images from, say, the Google Pixel 9 Pro XL, but it's a bold style that doesn't look bad at all. There's plenty of detail too, although the Oppo's preference for strong contrast can crush details in scenes with lots of light and shade.

The X8 Pro also held up well in my zoom tests, doing a fine job of picking up detail at 6x magnification. You can go further with digital zoom: Oppo claims its new "AI Telescope Zoom" mode produces clear photos even at 10x magnification and greater, and I found the Find X8 Pro produced cleaner, more detailed images at 10x zoom than the Samsung Galaxy S24 Ultra.

One last thing I like about the Find X8 Pro camera is its minimal shutter lag. I found it responsive even when rapidly firing off multiple shots, which makes the photographic experience easy and enjoyable.

Inside, the Oppo Find X8 Pro is driven by a MediaTek Dimensity 9400 chip. It's an unusual choice, but you can't argue with results: in Geekbench the Find X8 Pro beat the Snapdragon 8 Gen 3-powered OnePlus 12 in both single-core and multicore tests, and even beat the iPhone 16 Pro Max in the multicore test. It also outperformed its rivals in the Wild Life Extreme Unlimited GPU test, so whether it's productivity apps or graphics-heavy games you want, you're well covered.

Another unusual feature is the silicon-carbon battery. This has a high 5,910mAh capacity, and the Oppo ran down more slowly than other phones: playing three hours of YouTube videos ran down the charge by 14%, while the Galaxy S24 Ultra dropped by a huge 21% in the same time. You can recharge at up to 55W via a USB PD-compatible charger, or splash out on the 80W SuperVOOC wired charger; this refilled the phone from empty to 46% full in only 15 minutes. 50W AirVOOC wireless charging is supported too.

The Find X8 Pro runs Oppo's Android-based ColorOS, and comes with a promised five years of updates, plus an extra year of security updates. Inevitably, the latest version includes all the usual AI features, including summarisation, translation, audio transcription, text generation and photo-editing tools. However, Oppo does better than most in making them conveniently available, via an AI toolbar that swipes in from the side of the screen with context-based tool suggestions.

Overall the Oppo Find X8 Pro is a compelling alternative to the latest Google and Samsung phones. You won't find a quad-camera array anywhere else for this price, and it comes with strong battery life, a handsome screen, competitive performance and bags of storage. Since it's arrived late in the season, you might consider waiting to see how it measures up against the next generation of competing handsets – but the Find X8 Pro has enough going for it that you're very unlikely to regret buying it now.

RICHARD PRIDAY

PC PRO RECOMMENDED

"The Find X8 Pro demands attention with a big, bright display, four cameras, a huge battery and a reasonable price"

ABOVE The quad-camera set up is better than anything else at this price

BELOW A touch-sensitive Quick button lets you open the camera in an instant

SPECIFICATIONS

8-core MediaTek Dimensity 9400 SoC • 16GB RAM • Immortalis-G925 graphics • 6.8in 120Hz AMOLED screen, 1,264 x 2,780 resolution • 5G • 512GB storage • dual nano-SIM • IP68 • quad 50MP/50MP/50MP/50MP rear cameras • 32MP front camera • Wi-Fi 7 • Bluetooth 5.4 • NFC • 5,910mAh battery • USB-C 3.2 Gen 2 connector • Android 15 (5 major updates) with ColorOS 15 • 77 x 8.2 x 162mm (WDH) • 210g • 2yr warranty

ThinkPhone 25 by Motorola

A great choice for a business phone due to its size and quality, and it's reassuringly secure, too

SCORE ★★★★☆

PRICE £375 (£450 inc VAT)
from motorola.co.uk

Last month I gave a largely positive review to the Moto G75 5G Business Edition (*see issue 364, p72*), a great-value phone for business but one that I warned might be too large to act as a second phone. As if reading my mind, Motorola sent me the new ThinkPhone 25 – which is a pocket-friendly phone for business, albeit one that comes in at almost twice the G75's price.

It certainly looks like a business phone, with a patterned rear that echoes Lenovo ThinkPads; a move that makes sense not only due to the ThinkPhone name but because Lenovo owns the Motorola brand. With so many phones growing larger – just look at the three other phones we review this month – the fact the ThinkPhone 25 includes a 6.4in screen and measures a trim 154 x 71 x 8.1mm is welcome. It will fit comfortably, snugly even, in most people's hands, and barely makes an impact in a jacket or jeans pocket.

While mini, it's built for rough and tumble. The display is protected by Corning Gorilla Glass 7i, which isn't a match for Gorilla Glass 7 but – according to Corning – is twice as scratch-resistant as competitors' glass and can survive drops onto asphalt-like surfaces from a metre. The ThinkPhone 25 has also been certified as MIL-STD-810H compliant by SGS, an independent testing, inspection and certification company, while the usual IP68 protection is promised against water and dust.

Motorola also promises that this dinky phone will receive a reassuring five OS upgrades during its life, along with security updates into 2029. Which brings me to the software itself, which is essentially native Android 14 with a bunch of useful Motorola customisations. These are well worth investigating if you're new to Moto phones, with gestures such as a three-finger screenshot and a sharp double-shake to activate the torch. These quickly become instinctive.

ABOVE Business class: the ThinkPhone 25 is designed to last for a good few years

The business angle comes via the integration of ThinkShield and Moto Secure. ThinkShield includes hardware features such as secure booting – making it more difficult for anyone to physically hack into a device – and what Motorola describes as "elevated security features". It should also fit neatly into any mobile device management solution you're currently running. Moto Secure revolves around privacy features, such as being able to tuck sensitive data or apps into a PIN-protected folder.

You get these services until 2029, and as always nothing is free. While you won't pay another penny, the £450 price of this phone is higher than the specs would suggest. For example, MediaTek's Dimensity 7300 scores almost identically to the Qualcomm Snapdragon 6 Gen 3 chip in the G75, and while I have no complaints about this phone's speed – in fact, it's incredibly quick to respond to commands – you could buy a significantly faster phone for this price. Nor is it geared to avid gamers, as a 3,167 (19fps) result in 3DMark Wild Life indicates.

The same is also true for photographers, but if you're going to be taking snaps – whether for work or pleasure – then it's up to the job. Choose the main 50MP rear camera and colours look natural, it produces nice portraits and also copes well in lower light conditions. Only when you zoom in will you realise that there's a lack of detail to back up the strong first impression. The other two cameras feature fewer megapixels, but the 13MP ultrawide camera is handy for group shots, and surprisingly good at macro-style photos, while it's always handy to have a 3x optical zoom to call upon.

Motorola opts for a pinhole approach to accommodate the 32MP selfie camera, but it still performs better than most webcams – which I mention because if you download Smart Connect to your Windows PC then the phone's camera becomes an option during calls. You can also use the rear camera, or switch between them. It's a nifty feature.

The screen is yet another high-quality inclusion, using OLED technology to produce colour-drenched images. In its Vivid mode, it covers 100% of the DCI-P3 gamut with an average Delta E of 0.69, but switching to Natural mode locks the colour space to sRGB (100% coverage, 107% volume, 0.81 Delta E). It's also incredibly sharp, with 1,260 x 2,670 pixels converting to 462dpi.

Pushing the brightness up to its maximum of 507cd/m² means it's easy to read outside, but you're better off keeping it in adaptive brightness mode. This also conserves battery life, which is a semi-precious resource. Push this phone heavily – 5G, GPS, gaming, videos – and you'll be fortunate to have much left at the end of the day. Luckily it comes with a 68W charger that takes the phone from zero to 50% in 11 minutes, and it supports 15W wireless charging, too.

In the UK, Motorola is only selling the 8GB/256GB version of the ThinkPhone, and there's no microSD slot to add more storage. Also, it only comes with one nano SIM slot. With Wi-Fi 6E and Bluetooth 5.4 on board, though, it's tough to moan about this phone's connectivity. In fact, it's hard to moan about the ThinkPhone 25 at all. It's expensive when you consider the mid-range specification, but there's still enough power to last for its likely five-year life. And it comes with the right pedigree of software to keep it safe throughout. **TIM DANTON**

PC PRO RECOMMENDED

"The screen is yet another high-quality inclusion, using OLED technology to produce colour-drenched images. It's also incredibly sharp"

LEFT The dimensions of the phone make it easy to hold and carry

SPECIFICATIONS

8-core MediaTek Dimensity 7300 SoC • 8GB RAM • Mali-G615 MC2 graphics • 6.4in 120Hz AMOLED screen, 1,220 x 2,670 resolution • 5G • 256GB storage • nano-SIM • IP68 • triple 50MP/13MP/10MP rear cameras • 32MP front camera • Wi-Fi 6E • Bluetooth 5.4 • NFC • 4,310mAh battery • USB-C 2 connector • Android 14 (5 major updates) • 71 x 8.1 x 154mm (WDH) • 171g • 1yr RTB warranty

Asus ROG Phone 9 Pro

A new chipset and excellent cooling make this the most powerful phone we've tested – it's great for gaming

SCORE ★★★★☆

PRICE £917 (£1,100 inc VAT)
from rog.asus.com/uk

Asus' ROG phones are intended to be the best gaming choices around, and the ROG Phone 9 Pro comes with an amazingly powerful new Snapdragon 8 Elite chipset, a huge 16GB of RAM and 512GB of storage – not to mention the longest-lasting battery we've ever tested.

Naturally those features aren't of interest only to gamers, and the ROG Phone 9 Pro looks low-key enough to make a respectable everyday phone. The matte glass back and aluminium side are tasteful, as is the sober Phantom Black finish. The only real giveaways are the subtle ROG logos dotted about the case and the programmable "AniMe" LED display on the rear – but you can keep that turned off when not in use.

One quirky feature is the off-centre USB-C port on the bottom edge, while a second USB-C port on the side means you can keep it plugged in while gaming in landscape mode. There's a wired headphone socket, plus IP68 dust and water resistance and Gorilla Glass Victus 2 to protect the display.

That display is a big 6.8in AMOLED screen, which is gloriously bright and colourful. It's also exceptionally smooth, with an adaptive refresh rate of 1-120Hz, plus an ultra-fast 185Hz mode. So far I haven't found a game that runs at that speed, but hopefully one may come along in the future, and when it does the ROG Phone 9 Pro will be ready for it.

At the rear of the phone is a 50MP main camera with a new sensor and enhanced gimbal stabilisation, alongside a 13MP ultrawide and a 32MP telephoto with 3x magnification. A nice touch is that the capacitive "AirTrigger" sensors on the edge of the ROG Phone, primarily intended as shoulder buttons for gaming, can also release the shutter.

You can't fault the main camera for detail: I found my test snaps compared well even to the Samsung Galaxy S24 Ultra's 200MP sensor. However, whichever camera you use, the ROG Phone 9 Pro's colour reproduction is much less vibrant than the Samsung's, to the point that things look distinctly dull and grey. You can edit your images to improve the results, but it's a pain that you have to.

ABOVE Despite being a gaming phone, the powerful ROG Phone 9 Pro looks classy

Inside the phone you'll find the new Snapdragon 8 Elite chipset, which is probably the best chip that any Android phone will get in 2025. The ROG Phone 9 Pro came close to the Apple iPhone 16 Pro Max in our CPU benchmarks, and beat it on graphics performance. That's in standard mode, too; there's also a performance-boosting "X Mode" that unleashes the full power of the chip, beating Apple's and Samsung's finest with ease. To maximise your battery life you may not want to use X Mode all the time, but you can set it to kick in automatically when opening certain games and apps.

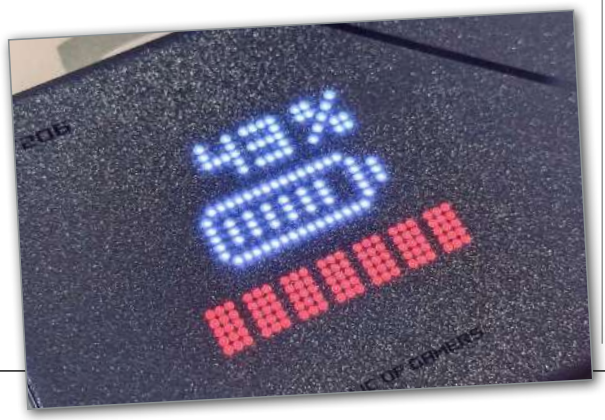
Even if you do hammer the hardware, a huge 5,800mAh battery gives the ROG Phone 9 Pro excellent stamina in everyday use. We measured an astonishing 20hrs 34mins of continuous web browsing on a full charge, beating the Apple iPhone 16 Pro Max by over three hours, and the Samsung Galaxy S24 Ultra by almost four. When it's time to recharge, the included 65W charger topped up the battery from empty to 74% in half an hour, and there's also support for 15W wireless charging.

Although the ROG Phone 9 Pro is based on regular Android 15, it comes with an extensive Asus skin that adds various game-oriented visuals and tools. New AI-powered gaming features include X Sense AI, which can automate in-game tasks such as setting up auto skill upgrades or skipping through cut scenes, and X Capture, which detects big moments and automatically records the screen. There's also AI Grabber, as previously seen on the ROG Phone 8 series, which reads and remembers onscreen text so you can review it later for details and hints.

There's a familiar set of non-gaming AI features, too, including AI call translation, voice note transcription, prompt-based wallpaper generation and semantic search for photos, along with the Circle to Search feature that was previously exclusive to Samsung and Google phones. The only catch is that the ROG Phone 9 Pro is only guaranteed two years of full Android updates; while you do get five years of security support, it's a letdown when Google and Samsung phones promise seven years of full updates.

"Even if you're not a gamer you might well be attracted by its awesome performance, sharp looks and excellent battery"

If you're looking for the best gaming phone you can buy right now, the Asus ROG Phone 9 Pro is undoubtedly the one. Even if you're not a gamer you might well be attracted by its awesome performance, sharp looks and excellent battery. Unfortunately its lacklustre photos, limited software support and high price make it a questionable choice as an all-round mobile companion; you're probably best to think of it as a great gaming phone, and consider any other use a bonus. **RICHARD PRIDAY**



BELOW You can turn off the programmable LED display on the rear if you wish

SPECIFICATIONS

8-core Snapdragon 8 Elite SoC • 16GB/24GB RAM • Adreno 830 graphics • 6.8in 120Hz AMOLED screen, 1,080 x 2,400 resolution • 5G • 512GB/1TB storage • dual nano-SIM • IP68 • triple 50MP/32MP/13MP rear cameras • 32MP front camera • Wi-Fi 7 • Bluetooth 5.4 • NFC • 5,800mAh battery • 2 x USB-C connectors • Android 15 (2 major updates) • 77 x 8.9 x 164mm (WDH) • 227g • 1yr warranty

RedMagic 10 Pro

Only worth considering if your priorities are gaming and battery life, but you can't argue with the price

SCORE ★★★★☆

PRICE 256GB, £483 (£579 inc VAT) **from redmagic.gg**

While Asus aims high with its ROG Phone 9 Pro opposite, the RedMagic 10 Pro opts for affordability. It runs on the same Snapdragon 8 Elite silicon as its classy competitor, and while the experience is nowhere near as polished, it's one heck of a performer for the price.

That starts at just over half the cost of the Asus phone: you'll pay £579 for the Shadow finish with 12GB of RAM and 256GB of internal storage, or £709 for the Moonlight and Dusk finishes, which come with 16GB of RAM and 512GB of storage. There's also a range-topping Dusk Ultra model, which ups the specs to an absurd 24GB of RAM and 1TB of storage, but at £879 it's still much cheaper than the Asus.

The 6.9in screen dominates the front of the phone, with tiny bezels measuring 1.25mm. A selfie camera is hidden under the display, and the camera section at the rear doesn't protrude, so the only likely pocket snags are from the circular power button and the physical slider on the right that launches the Gamespace utility – about which more later.

Also on this side of the phone are two capacitive trigger controls and a vent for the internal cooling fan, one of the distinguishing features of a true gaming phone. These are all positives, but I have a few practical issues with the design. The tiny bezels mean your hands can get in the way when gaming in landscape mode, and audio is uneven as the earpiece serves as the left speaker, while the right one points out of the bottom edge. The sole USB-C port is also on the bottom, so it's not convenient to charge while you game, and the open vents mean the handset isn't water-resistant.

Still, the full-frontal AMOLED screen presents a glorious canvas for gaming, with punchy colours and deep blacks. Its maximum refresh rate of 144Hz is higher than most games can currently support, and brightness is great, too, with a localised peak of 2,000cd/m².

One area where costs have been cut is the cameras. The primary sensor captures good shots in favourable lighting conditions, but it struggles with blown-out highlights and can exaggerate colours. The ultrawide camera has a smaller sensor, so it picks up less detail and also has a rather pale tone. There's no optical zoom, and while 2x digital zoom shots look respectable, things quickly become soft if you push further.

The 16MP front camera, meanwhile, has its own problems: its placement behind the screen reduces the amount of light reaching the sensor, resulting in noisy selfies. Overall it's hard to drum up much enthusiasm for the RedMagic 10 Pro as a camera phone.

Still, the most important thing for a gaming phone is performance, and the RedMagic 10 has that in bags thanks to Qualcomm's Snapdragon 8 Elite SoC. Across multiple benchmarks it delivered around 40% better CPU performance than phones using older Snapdragon 8 Gen 3 chips, and 24% better GPU performance.

Even better, it can keep this up all day without throttling. In 3D Mark's Solar Bay Stress Test, the Red Magic 10 Pro scored a near-perfect 99.8% – thanks to that built-in active fan – and the huge 7,050mAh battery should easily see you through a full day, even with intensive gaming sessions. Recharging is swift, too: the bundled 80W charger took me from empty to full in a mere 40 minutes. However, there's no wireless charging.

Nubia's Android-based RedMagic OS is a mixed bag. The initial experience isn't great, with blocky icons, a cluttered notification menu and a needlessly huge widget for turning the fan on and off, not to mention preinstalled bloatware. On the plus side, the whole thing feels snappy, and I appreciated the option to choose between gesture and virtual navigation at the outset. Buried in the Themes settings, there's an option to switch to regular round Android icons too.

ABOVE The RedMagic 10 Pro is an affordable gaming phone with an enormous battery

The other positive is the aforementioned Gamespace tool for tweaking things such as screen sensitivity and resolution settings. You can manage plug-ins for individual games, too, and access cheat-like features such as enhanced zoom and sound equalisers. It's just a shame that Nubia only promises one major OS upgrade, to Android 16, with three years of security updates – nowhere near the industry leaders.

If you're looking for huge gaming performance on a small budget, the RedMagic 10 Pro is a brilliant deal. Sure, the physical design is hit and miss, the camera system is uninspiring and the general OS experience can be clunky. Even so, this phone has all the necessary power to play high-end games for hours on end, with programmable trigger buttons and neat extra software features. Considering the price, that's very hard to complain about. **JON MUNDY**

> **"The full-frontal AMOLED screen presents a glorious canvas for gaming, with punchy colours and deep blacks"**

SPECIFICATIONS

8-core Snapdragon 8 Elite SoC • 12GB/16GB RAM • Adreno 830 graphics • 6.9in 144Hz AMOLED screen, 1,216 x 2,688 resolution • 5G • 256GB/512GB storage • dual nano-SIM • IP68 • triple 50MP/50MP/2MP rear cameras • 16MP front camera • Wi-Fi 6 • Bluetooth 5.4 • NFC • 7,050mAh battery • USB-C 3.2 Gen 2 connector • 3.5mm audio jack • Android 15 (1 major update) with RedMagic OS 10 • 77 x 8.9 x 164mm (WDH) • 229g • 2yr warranty

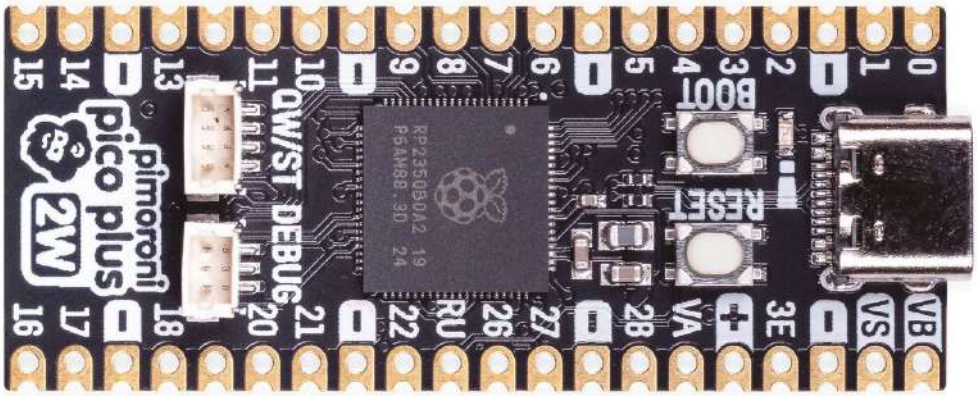
LEFT Two trigger controls and a slider to launch Gamespace adorn the phone's side

Pimoroni Pico Plus 2 W

A powerful, versatile board that brings Wi-Fi to the RP2350B while retaining the familiar Pico form factor

SCORE ★★★★☆

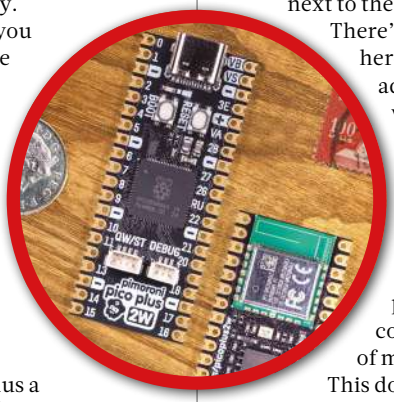
PRICE £14 (£17 inc VAT)
from shop.pimorini.com



ABOVE The Pico Plus 2 W is even more versatile than the official board

I was impressed by the Raspberry Pi Pico 2 W (*see opposite*), but if you want to explore more ambitious projects, take a look at this third-party remix. Based on the same RP2350 chipset, Pimoroni's Pico Plus 2 W replicates everything that's good about the official board, while adding extra resources and capabilities for even more versatility.

The first change you might spot is that the main SoC is much larger than the one on the Raspberry Pi Pico 2 W. In place of the basic RP2350A chip, Pimoroni has used the RP2350B, which has the same twin-architecture design (dual Arm Cortex-M33 cores plus a pair of RISC-V cores) but supports 48 GPIO pins versus the 30 of the standard version. The Pico Plus 2 W also comes with a relatively huge 8MB of extra memory in addition to the base 520KB of RAM, and the onboard storage is boosted from 4MB to 16MB. This is a board that's ready for big things.



While the extra GPIO connections are a handy extra, they won't cause compatibility problems, as the first 30 pins are the same as on the standard Pico. Indeed, the all-black PCB features a white silkscreen print that identifies each pin – a wonderfully useful piece of design that really helps you get on with projects without needing to stop and check which pin does what. It's a shame that SPI, UART and analogue pins aren't marked, but there's only so much space on the board.

Like a regular Pico board, the Pimoroni Pico Plus 2 W comes without physical GPIO pins installed, so if you want to use these you must solder them in place yourself. This is a breeze with a standard soldering iron, and the castellated edges mean the board can also be surface-mount soldered to a carrier board. Note, however, that the RM2 wireless and Bluetooth breakout board is mounted on the underside of the Pico Plus 2 W, so if you want to mount it directly onto another board you'll need to cut a section out of the PCB.

The extra GPIO connections for QW/ST and SWD debug meanwhile connect to ports on the top of the unit, next to the boot select button. There's a reset button here, too – a handy addition that you won't find on an official Pico board – and another neat enhancement is the use of USB Type-C for the power and data connection instead of micro-USB. This doesn't make a practical difference to the working of the board, but the cables are easier to come by these days, and aren't finicky about which way round you plug them in.

To get the most from the Pico Plus 2 W you'll need to use Pimoroni's custom firmware, which provides access to the full 16MB of storage. In practice this works just like the regular Pico firmware: the board is programmed in the same manner, using MicroPython or other languages on a host computer, and the code for accessing the GPIO hardware and making Wi-Fi connections is exactly the same.

That last part should be no surprise, as the Pico Plus 2 W uses the same wireless module as the official Pico 2 W. This means you needn't worry about compatibility, but don't expect lightning-fast transfers; as I've noted opposite, this is an unassuming Wi-Fi 4 chip, and has no external antenna to help with range or performance. Still, once I got connected I found everything ran smoothly, with no hitches when pulling data in from online JSON feeds and publishing my own content to the internet. I even managed to connect the Pico Plus 2 W to Bluesky, and use a custom MicroPython script to post and receive messages.

PC PRO RECOMMENDED

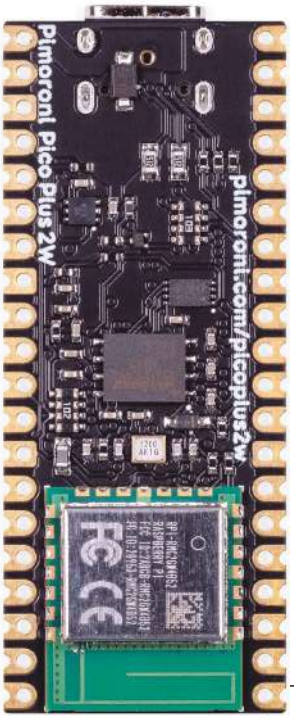
"The Pico Plus 2 W is a great little board with oodles of potential and some nice quality-of-life enhancements"

The Pimoroni Pico Plus 2 W won't be the right choice for everyone. Though it's loaded with good points, the specifications are excessive for typical Pico-scale projects, while the processor is more limited than a full-sized Pi board. It's also around three times the price of a standard Pico, so for the same money you could get a Pi Zero 2 W that's capable of running the Raspberry Pi desktop OS.

Make no mistake, though, the Pico Plus 2 W will find its niche. For example, the original Raspberry Pi Pico is already popular as a retro gaming device, emulating old computers such as the Sinclair ZX Spectrum, and with the RP2350B it's possible to play more demanding games like *Doom* at slick frame rates. I can't wait to see how enterprising creators harness the power that's on hand here to emulate more advanced machines.

In short, the Pico Plus 2 W is a great little board with oodles of potential and nice quality-of-life enhancements, in a form factor that's cleaner and more compact than a standard Pi. For many purposes you'll be fine with the standard Pico 2 W board, or even an old-school Pico W, but for anyone seeking to push the envelope with their Pico projects it's a superb choice. **LES POUNDER**

LEFT A white silkscreen print makes it easy to identify each pin



LEFT The main SoC is much larger than the one on the Pi Pico 2 W

SPECIFICATIONS

RP2350B SoC with 150MHz dual-core RISC-V processors • 520KB SRAM • 8MB flash memory • 2.4GHz Wi-Fi 4 • Bluetooth 5.2 • 26 x Digital IO • 2 x UART • 2 x SPI • 2 x I2C • 26 x PWM • 4 x 12-bit ADC channels • USB 1.1 controller and PHY • 12 x PIO state machines • 21 x 51mm (WD) • limited warranty

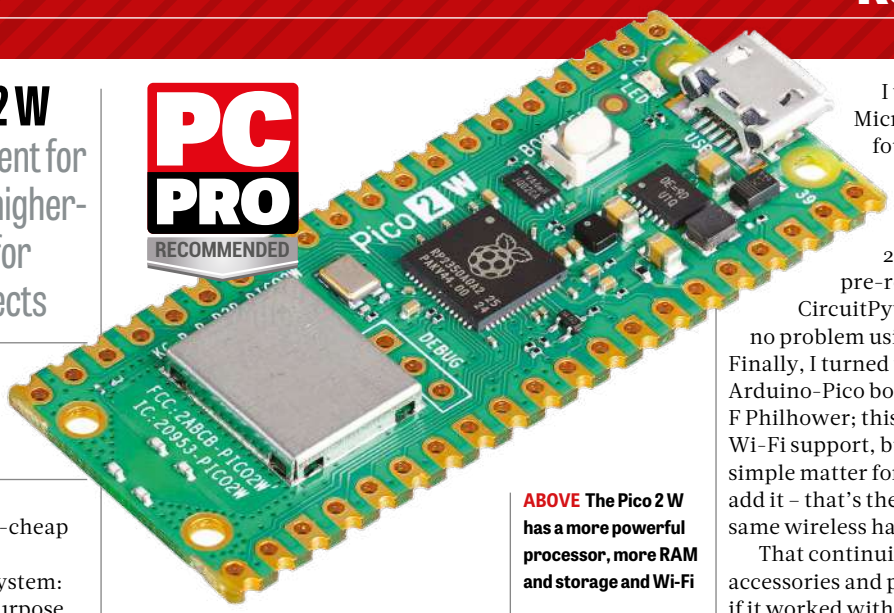
Raspberry Pi Pico 2 W

This drop-in replacement for the Pico W provides a higher-spec microcontroller for more demanding projects

PC PRO RECOMMENDED

SCORE ★★★★★

PRICE £5.50 (£6.60 inc VAT) from thepihut.com



ABOVE The Pico 2 W has a more powerful processor, more RAM and storage and Wi-Fi

Launched in 2021, the dirt-cheap Raspberry Pi Pico was a departure for the Pi ecosystem: rather than using a general-purpose Arm processor from Broadcom, it was based on Raspberry Pi's own RP2040 microcontroller. While not powerful enough to run a full Linux desktop, this tiny board was perfect for simple project duties at an almost laughably low price, with the Pico W version adding integrated Wi-Fi.

A follow-up came earlier this year in the form of the Pico 2, which offered a more powerful processor plus more RAM and storage, and the latest update brings Wi-Fi on board as well, giving you the freedom to situate the board more or less wherever you want it. For under £7 it's incredibly versatile.

LEFT The new model includes a dual-core Arm Cortex-M33 CPU

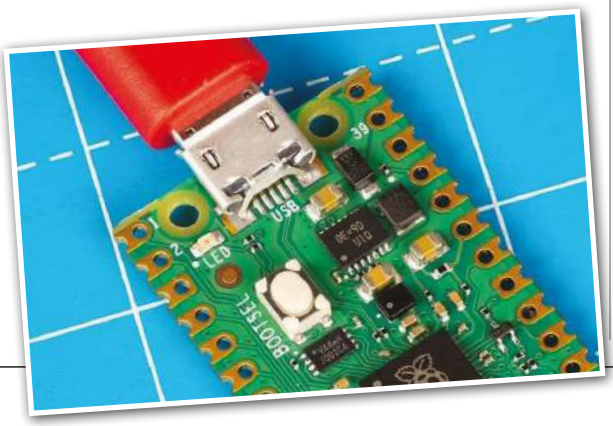
It might seem silly to talk about the "design" of a single-board computer that measures only 21 x 51mm, but for what it's worth the Raspberry Pi Pico 2 W looks just like the original Pi Pico W. The only visible differences are the branding text and the arrangement of the surface mount components; happily, you still get those wonderful castellated edges, making it easy to mount the board without the need to modify the receiving PCB, and holes for soldering in GPIO pins if required.

What sets the latest Pico 2 boards apart from the original Pico models is the core silicon. In place of the old RP2040 chip, which was based on a dual-core Arm Cortex-M0+ CPU, the new models introduce the much souped-up RP2350. As well as including a more capable dual-core Arm Cortex-M33 processor, this features a pair of Hazard3 RISC-V cores, which you can switch to if you're interested in trying out the open RISC architecture.

I wouldn't have minded if Raspberry Pi had made a few more changes. The big silver square at the bottom of the board contains the same CYW43439 wireless package as found on the Raspberry Pi Pico W, which means you're limited to 802.11n (or Wi-Fi 4) on the 2.4GHz band. By modern standards this is very slow – you're unlikely to get more than 10Mbits/sec – but it's fast enough for almost any Pico-scale project, and will work with any wireless router.

Similarly, power and data are still provided over a 12Mbits/sec micro-USB connector, which in 2025 is starting to feel ancient. And the only physical control remains the BOOTSEL button that puts the board into firmware upload mode – please, Raspberry Pi, can we have a reset button on the next model?

Like full-sized Pi boards, the Pico 2 W can be programmed in Python, but first you'll need to flash its firmware with a microcontroller-compatible edition such as MicroPython or CircuitPython. The actual coding is then done on a host computer connected by USB, which could be a Raspberry Pi or a full-sized desktop running Windows, macOS or Linux. You can also use the Arduino C++ derivative, or many other languages.



BELOW Power comes from a 12Mbits/sec micro-USB connector

I tested the latest MicroPython release and found it worked out of the box with seamless Wi-Fi support on the Pico 2 W. I also tried out a pre-release version of CircuitPython and again had no problem using Wi-Fi features. Finally, I turned to the third-party Arduino-Pico board library from Earle F Philhower; this doesn't yet have Wi-Fi support, but it should be a simple matter for the maintainer to add it – that's the upside of using the same wireless hardware as the Pico W.

That continuity carries over to accessories and peripherals; as a rule, if it worked with the original Raspberry Pi Pico boards, it's likely to work on the Pico 2 W. For example, I tried the Pimoroni Pico Display 2.0 and Display 2.8, and in both cases I had a series of animated balls bouncing around the screen like a DVD screensaver in moments. For the few add-ons that don't work on day one, it shouldn't take long for developers to make the necessary updates.

> **"With its dual-architecture chipset and integrated Wi-Fi, the Pico 2 W is the most versatile Pico board around"**

So, should you buy the Pico 2? As usual with Raspberry Pi hardware, it's a case of horses for courses. If you want to run a full desktop interface you'll need a more powerful Pi with a Broadcom chipset; conversely, if your project requires nothing more than basic data collection or GPIO control, you could happily stick with the original Pico and Pico W boards, which are still available for less than £4. If you don't require wireless connectivity, the standard Pico 2 might be a better fit.

Clearly, though, with its dual-architecture chipset and integrated Wi-Fi, the Pico 2 W is the most versatile Pico board around. It's ideal for any task that involves pulling in data from sensors or remote sources, processing it on the board and forwarding it to (for example) a full-fat Pi running the main project code. That might mean data-science applications, robotics or basic machine learning – and even if it's overkill for your current needs, for just a few quid more than the original board the Pico 2 W gives you plenty of scope for repurposing in the future. **LES POUNDER**

SPECIFICATIONS

RP2350A SoC with 150MHz dual-core RISC-V processors • 520KB SRAM • 4MB flash memory • 2.4GHz Wi-Fi 4 • Bluetooth 5.2 • 26 x Digital IO • 2 x UART • 2 x SPI • 2 x I2C • 24 x PWM • 3 x 12-bit ADC channels • USB 1.1 controller and PHY • 12 x PIO state machines • 21 x 51mm (WD) • limited warranty

Raspberry Pi Touch Display 2

A great upgrade to the original Touch Display, especially if you need five-point touch and an HD screen

SCORE ★★★★★

PRICE £47 (£56 inc VAT)
from thepihut.com

PC PRO RECOMMENDED

The original Raspberry Pi Touch Display debuted in 2015, enhancing the standard Pi with a tablet-like interface for digital signage, interactive displays and entertainment. Now, after a decade, this new model brings a higher resolution and useful extra features for the same price as before.

At first glance it looks very similar to the old version, with the same chunky bezels and the same 7in display format (although this model has a slightly wider 16:9 aspect ratio, rather than the 5:3 shape of the original).

Hooking up is easier than before, however. Where the original Touch Display required an external driver board, the new model has that built in, and connects directly via a ribbon cable to the CAM/DISP1 port on your Pi, with power coming from a second cable connected to the Pi's GPIO header. The Pi attaches to the rear of the screen like a backpack, using the included M2.5 machine screws.

You couldn't really ask for a neater design. I love how the cables neatly tuck away, and the screen and Pi become one unit that can be mounted in an enclosure. The use of the GPIO for power does cramp your creative options, though, as it means you can't combine the display with a HAT+ board. There's no obvious reason why it couldn't have used one of the Pi's four USB ports for power instead, or given you the option of using an external brick. Still, if you're the sort of person who wants to use HAT+ boards, I'm sure your maker mind will already have come up with a workaround.

The assembly also feels a little fragile. The bezel extends well beyond the casing at the rear, and is only 2mm thick, so an accidental drop onto a hard surface could break it. For the price, though, you can't complain too much.

Software support for the Touch Display 2 is built into the latest version of the Raspberry Pi OS, so once the cables are connected you simply need to update your existing installation, or flash a fresh image using Raspberry Pi Imager, and you're ready to go. I tested the display with a Raspberry Pi 5, but it will work with any full-sized Pi board from the 2014 Model B+ onwards.

When you first power up with the display attached it defaults to portrait mode. This feels a little retro – with the large bezel it reminded me of the old Google Nexus 7 – but a new configuration tool called raindrop lets you rotate it in 90° increments, and adjust the brightness to suit your environment. Raspberry Pi hasn't published any official figures for brightness, but I found the display perfectly clear and readable even at 60%. It helps that, where the old Touch Display had a native resolution of 480 x 800, the new one is 720 x 1,280, so you get well over twice as many pixels for a much sharper image.

ABOVE The 7in touch display has a sharp 720 x 1,280 resolution

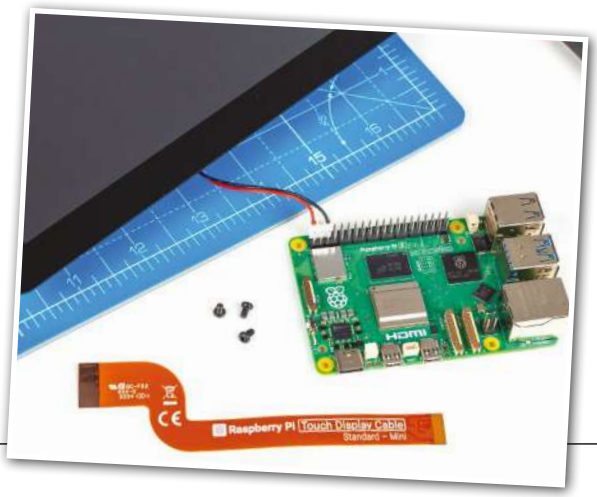
"The Touch Display 2 works very well. It's effortless to install and use, so you can focus on the functional aspects of your projects"

LEFT Your Pi attaches to the rear of the screen like a backpack

The other new feature is the onscreen keyboard. This put me in mind of an Android tablet, and I found it generally responsive and precise. It makes it possible to fully operate the Pi without plugging in an external input device – but I do have one caveat here. While you can use the touchscreen to swipe around the Pi OS, just as on a tablet, this doesn't work in all apps: in the Chromium and Firefox web browsers, I couldn't drag web pages up and down, and had to use the razor-thin scroll bar. This isn't exactly a fault of the Touch Display 2 – clearly these third-party applications need an update to work with the touchscreen – but until that arrives, it greatly reduces the usefulness of the display.

If you're thinking of using the Pi as an always-on dashboard, you might be wondering how much power the Touch Display 2 consumes. As a baseline, with the display disconnected, I found my Raspberry Pi OS drew 4.4W of power, settling down to 2.6W once everything had finished loading. When I added the Touch Display 2, with brightness set to 100%, the peak boot power load went up to 7.5W, settling down to 5.3W once the desktop appeared. In other words, the screen raises consumption to just over double that of a headless board. It's not going to wreck your electricity bills, but it's worth knowing if you want to integrate the Touch Display 2 into a battery-powered build.

In all, the Touch Display 2 works very well. It's effortless to install and use, so you can focus on the functional aspects of your projects, and while it would have been nice to see an official external power option, makers should get along with it just fine. It's not ideal as an everyday screen for your Raspberry Pi: aside from inconsistent support in third-party apps, it's too small for regular desktop use. But for applications that need a touchscreen in a compact, self-contained package, this is the kit to get. I can immediately see its appeal for home automation and data monitoring, 3D printer monitoring, home lab setups and any number of other projects. **LES POUNDER**



BELOW Power comes via a cable connected to the Pi's GPIO header

SPECIFICATIONS

7in capacitive touchscreen, 720 x 1,280 resolution • 5-touch support • compatible with all models of Raspberry Pi from the B+ (incompatible with Pi Zero range) • 120 x 8.6 x 189mm • limited warranty

Raspberry Pi SSD

If you want guaranteed SSD compatibility for your Pi 5, pay the premium for this speedy drive

SCORE ★★★★☆

PRICE 256GB, £23 (£28 inc VAT); 512GB, £35 (£42 inc VAT) **from thepihut.com**

ABOVE Transfer speeds are impressive for such a tiny drive

Raspberry Pi released a torrent of accessories and add-ons in the final weeks of 2024, including its own-branded SSDs. These take advantage of the Raspberry Pi 5's dedicated PCI-E connection, into which you must slide a Pi M.2 HAT+ (£11.50 inc VAT) or one of its third-party alternatives (such as the excellent £9 Pinboards HatDrive! Nano). If you have one already, buy the "naked" SSD; if not, you can buy it as part of the SSD bundle: £37 for 256GB, £51 for 512GB.

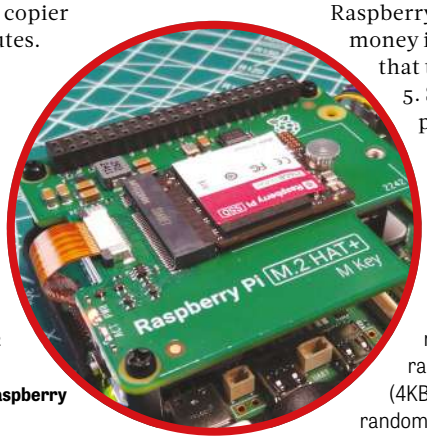
I used the Raspberry Pi M.2 HAT+ as part of the SSD kit. To install Raspberry Pi OS to the NVMe SSD, I installed the SSD, connected all of the peripherals and inserted a microSD card with the latest OS. I then powered up the Raspberry Pi 5 and copied the install from the card to the SSD using the SD card copier tool. It barely took five minutes. I then set the Raspberry Pi to boot from NVMe, and set the PCI-E speed to Gen 3. A quick reboot and I was ready for testing.

The 256GB Raspberry Pi SSD boots to the Raspberry Pi OS desktop in 19.92 seconds. That's faster than a microSD card, but the new Raspberry Pi A2 microSD cards come in at 22.71 seconds. There isn't much difference between the two.

Using a test that uses dd to read the entire drive to /dev/null, it read data at an impressive 837MB/sec, in line with all the other M.2 NVMe drives I've tested with the Raspberry Pi. I used the Raspberry Pi Diagnostics application to test sequential write speeds, where it ran at 723MB/sec; plenty of speed for the Raspberry Pi, and again, in line with other drives that I've tested.

All of which means that you're paying a few pounds more for the Raspberry Pi brand, but that extra money is well spent as it ensures that the drive will work on the Pi 5. Sure, you can save £10 and pick up an M.2 2230 drive from Amazon, but you're taking a compatibility risk.

LES POUNDER



RIGHT The drive attaches to your Raspberry Pi 5 via an M.2 HAT+ add-on

SPECIFICATIONS

M.2 2230 NVMe SSD • PCI-E Gen 3 • 256GB: 40K IOPS (4KB random reads), 70K IOPS (4KB random writes) • 512GB: 50K IOPS (4KB random reads), 90K IOPS (4KB random writes) • limited warranty

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Experience seamless connectivity with our fastest access points yet, powered by WiFi 7.

zyxel.com

SCAN ME

Printers *for* PROs

We put 14 inkjet and laser printers through their paces in our exhaustive tests for quality and speed so that you can buy with confidence

We'd love to tell you that you could buy a brilliant printer for £100. One that would last for years, that would product great-quality prints for extraordinarily low prices, that would be so easy to use that you'd laugh with joy every time you pressed Print or Scan. But reality is a harsh mistress.

Things are improving. Mostly. The growing maturity of ink tank printers means that these are now strong contenders. And they also lift the mask on an ugly fact: that the cost of all those luxury features, such as colour touchscreens and automatic document feeders, is borne through the tax of ink cartridges.

We can't review every ink tank printer on the market, but even if the Epson EcoTank ET-2865 and HP Smart Tank 7005 don't quite meet your requirements, then you can make an informed decision about their siblings with more or fewer features. And you can see exactly how much you're paying for them. There's an honesty to this we like.

Eight out of the 14 printers use laser technology. Traditionally this has been seen as a natural business choice, and there remains much truth to that. One of our award winners is purely aimed at business users. But more demanding buyers, for small businesses or even a busy household, should also consider this excellent technology for its low running costs and excellent text results. Some things, it turns out, don't change.

To accompany the reviews, we hope you find the feature comparison table overleaf and the buyer's guide on p82 useful. They're all there to help you make the most informed decision possible. Happy printing (and yes, it can happen).

CONTRIBUTOR: Simon Handby

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INKJETS

	Canon Pixma TR7650	Epson EcoTank ET-2865	Epson WorkForce Pro WF-C4310DW	Epson WorkForce WF-2960DWF	HP OfficeJet Pro 9135e	HP Smart Tank 7005
		RECOMMENDED			LABS WINNER	
Print technology	THERMAL INKJET	PIEZO INKJET	PIEZO INKJET	PIEZO INKJET	THERMAL INKJET	THERMAL INKJET
Overall	★★★☆☆	★★★★☆	★★★☆☆	★★☆☆☆	★★★★★	★★★☆☆
Information						
Price (inc VAT)	£151 (£181)	£194 (£233)	£96 (£115)	£67 (£80)	£161 (£193)	£183 (£220)
Supplier	printerbase.co.uk	uk.insight.com	printerland.co.uk	printerland.co.uk	printerbase.co.uk	amazon.co.uk
Manufacturer	canon.co.uk	epson.co.uk	epson.co.uk	epson.co.uk	hp.co.uk	hp.co.uk
Warranty	1yr RTB	1yr/30,000 pages RTB	1yr onsite	1yr RTB	1yr RTB	3yr exchange (with registration)
Dimensions (WDH)	438 x 350 x 190mm	375 x 347 x 179mm	425 x 378 x 164mm	375 x 347 x 231mm	496 x 377 x 489mm	428 x 364 x 199mm
Weight	7.9kg	3.9	5.8kg	6.4kg	11.9kg	6.4kg
Printing						
Max print resolution	4,800 x 1,200dpi	5,760 x 1,440dpi	4,800 x 2,400dpi	4,800 x 2,400dpi	4,800 x 1,200dpi	4,800 x 1,200dpi
Mono speed (claimed/ tested)	15ppm/11.1ppm	10ppm/8.8ppm	21ppm/19.7ppm	14ppm/14ppm	25ppm/22.1ppm	15ppm/13ppm
Colour speed (claimed/ tested)	10ppm/3.6ppm	5ppm/2.7ppm	11ppm/5.4ppm	7.5ppm/4.9ppm	20ppm/8ppm	9ppm/3.6ppm
Paper input (capacity)	Cassette (100), tray (100)	Tray (100)	Cassette (250), tray (80)	Cassette (150)	Two cassettes (500)	Cassette (250)
Paper output	Not stated	30	250	Not stated	100	100
Maximum paper size (weight)	A4/legal (300gsm)	A4/legal (300gsm)	A4/legal (255gsm)	A4/legal (300gsm)	A4/legal (280gsm)	A4/legal (250gsm)
Double-sided printing	✓	✗	✓	✓	✓	✓
Black cartridge (pages)	PGI-580PGBK XXL (600)	104 (3,600)	408L (2,200)	503XL (550)	HP 937e (2,500)	32XL (6,000)
Colour cartridge (pages)	CLI-581BK black (6,360), CLI-581C cyan (820), CLI-581M magenta (760) and CLI-581Y yellow (824)	104 cyan, magenta and yellow (6,500 each)	408L cyan, magenta and yellow (1,700 each)	503XL cyan, magenta and yellow (470 each)	HP 937e cyan, magenta and yellow (1,650 each)	31 cyan, magenta and yellow (8,000 each)
Cost per mono page (inc VAT)	2.9p (3.5p)	0.2p (0.2p)	1.7p (2p)	3.6p (4.3p)	2p (2.4p)	0.1p (0.2p)
Cost per colour page (inc VAT)	6p (7.2p)	0.3p (0.3p)	11.7p (14.1p)	10.8p (13p)	6p (7.2p)	0.3p (0.4p)
Monthly duty cycle (pages)	Not stated	Not stated	33,000 max	3,000 recommended	30,000 max, 2,000 recommended	5,000 max, 800 recommended
Other functions						
Max scan resolution	1,200 x 2,400dpi	1,200 x 2,400dpi	N/A	1,200 x 2,400dpi	1,200 x 1,200dpi	1,200 x 1,200dpi
Automatic document feeder	20 sheets	✗	✗	30 sheets	35 sheets	✗
Fax	✓	✗	✗	✓	✓	✗
Mobile/cloud features	AirPrint, Android, iOS, Mopria, Pixma Cloud Link, WLAN PictBridge	Android, Epson Connect, iOS	AirPrint, Android, Epson Connect, iOS	AirPrint, Android, Epson Connect, iOS	AirPrint, Android, Chrome OS, iOS, Mopria	AirPrint, Android, iOS, Mopria
Interface						
Display	7.5cm colour touchscreen	None	6.1cm colour screen	6.1cm colour touchscreen	10.9cm colour touchscreen	Mono LCD
Front connections	None	None	None	None	USB-A host	None
Rear panel	USB-A	USB-A	USB-A, 10/100 Ethernet	USB-A, 10/100 Ethernet	USB-A, 10/100 Ethernet	USB-A
Wireless	Wi-Fi 4	Wi-Fi 4	Wi-Fi 4	Wi-Fi 4	Wi-Fi 5	Wi-Fi 4
Power						
Sleep (W)	0	0	0	0	1	1
Standby (W)	4	4	4	3	6	4
Active (printing or copying, W)	13	15	21	13	22	16

LASERS

		LABS WINNER			RECOMMENDED		
Brother HL-L2865DW	**Brother MFC-L2980DW**	**Canon i-Sensys LBP243dw**	**HP Color LaserJet Pro MFP 3302fdw**	**HP LaserJet M209d**	**Kyocera Ecosys PA4000wx**	**Lexmark MS331dn**	**Xerox C410**
MONO LASER	MONO LASER	MONO LASER	COLOUR LASER	MONO LASER	MONO LASER	MONO LASER	COLOUR LASER
★★★☆☆	★★★☆☆	★★★★★	★★★★☆	★★☆☆☆	★★★★☆	★★★☆☆	★★★☆☆
£94 (£113)	£268 (£322)	£155 (£186)	£292 (£350)	£100 (£120)	£275 (£330)	£135 (£162)	£343 (£412)
printerland.co.uk	printerland.co.uk	printerbase.co.uk	printerbase.co.uk	hp.co.uk	printerbase.co.uk	printerbase.co.uk	printerbase.co.uk
brother.co.uk	brother.co.uk	canon.co.uk	hp.co.uk	hp.co.uk	kyoceradocumentsolutions.com	lexmark.co.uk	xerox.co.uk
1yr RTB	1yr RTB	1yr RTB	3yr exchange (with registration)	1yr RTB	2yr RTB (drum guaranteed for 3yr/100,000 pages)	1yr RTB	1yr onsite
444 x 449 x 366mm	410 x 421 x 319mm	399 x 373 x 249mm	418 x 420 x 342mm	355 x 280 x 205mm	375 x 393 x 272mm	368 x 363 x 222mm	455 x 423 x 318mm
7.1kg	12.4kg	9.5kg	17.1kg	7.3kg	14kg	9.3kg	20.6kg
1,200 x 1,200dpi	1,200 x 1,200dpi	1,200 x 1,200dpi	600 x 600dpi	600 x 600dpi	1,200 x 1,200dpi	2,400 x 600dpi	1,200 x 1,200dpi
34ppm/26.8ppm	34ppm/26.8ppm	36ppm/32.6ppm	25ppm/18.5ppm	29ppm/26.3ppm	40ppm/31.3ppm	38ppm/28.8ppm	40ppm/26.8ppm
N/A	N/A	N/A	25ppm/13.1ppm	N/A	N/A	N/A	40ppm/11.9ppm
Cassette and MP slot (251)	Cassette and MP slot (251)	Cassette and tray (350)	Cassette and MP slot (251)	Tray (150)	Cassette and tray (350)	Cassette and tray (350)	Cassette and MP slot (251)
150	120	150	100	100	250	150	125
A4/legal (230gsm)	A4/legal (230gsm)	A4/legal (199gsm)	A4/legal (200gsm)	A4/legal (163gsm)	A4/legal (220gsm)	A4/legal (217gsm)	A4/legal (200gsm)
✓	✓	✓	✓	✓	✓	✓	✓
TN2510XXL (5,000)	TN2510XXL (5,000)	070H (10,200)	219X (3,200)	135X (2,400)	TK-1260 (10,000)	MS/MX331 (15,000)	006R04685 (10,500)
N/A	N/A	N/A	219X cyan, magenta and yellow (2,500 each)	N/A	N/A	N/A	006R04686 cyan, 006R04687 magenta and 006R04688 yellow (7,000 each)
1.8p (2.1p)	1.8p (2.1p)	1.2p (1.4p)	2p (2.4p)	2.2p (2.6p)	1.1p (1.3p)	1.9p (2.2p)	1.4p (1.7p)
N/A	N/A	N/A	9p (10.8p)	N/A	N/A	N/A	7.8p (9.3p)
2,500 recommended	3,500 recommended	80,000 max, 4,000 recommended	40,000 max, 2,500 recommended	20,000 max, 2,000 recommended	Not stated	50,000 max, 5,000 recommended	125,000 max, 10,000 recommended
N/A	1,200 x 1,200dpi	N/A	1,200 x 1,200dpi	N/A	N/A	N/A	N/A
N/A	50 sheets	N/A	50 sheets	N/A	N/A	N/A	N/A
N/A	✓	N/A	✓	N/A	N/A	N/A	N/A
Android, iOS	Android, iOS, scan to email/SMB, Sharepoint	Android, iOS, Mopria	Android, iOS	None	Android, iOS, Kyocera Cloud Access, Mopria	AirPrint, Mopria	AirPrint, Android, Chrome OS, Mopria, iOS
Mono LCD	8.8cm colour touchscreen	5-line mono LCD	10.9cm colour touchscreen	None	Backlit mono LCD	Backlit mono LCD	10.9cm colour touchscreen
None	None	None	USB-A host	None	USB-A host	None	USB-A host
10/100 Ethernet	USB-A, 10/100 Ethernet	USB-A, 1Gb Ethernet	USB-A, 1Gb Ethernet	USB-A	USB-A, 1Gb Ethernet	USB-A, 10/100 Ethernet	USB-A, 1Gb Ethernet
Wi-Fi 4	Wi-Fi 4	Wi-Fi 4	Wi-Fi 5	✗	Wi-Fi 5	✗	Optional
0	0	0	2	0	0	0	0
2	2	5	8	2	6	5	37
955	948	665	675	647	789	833	580

Buyer's guide: how to buy the right printer for you

A printer should last you for years, so read this guide to make sure that you won't pay the price – literally and figuratively – of making a rushed decision

Let's face it, printers and multifunction peripherals aren't the most interesting items of technology you'll buy. And we know it's tempting to simply buy something on Black Friday or with a giant 40% off sign at the supermarket, but we're here to say one thing: don't.

More than almost any other piece of IT equipment, it pays to make an informed decision. Speed, quality, price and running costs can all vary considerably between models: buy the wrong device and you could find yourself paying over the odds, or even having to buy again.

Get the basics right

As always, the first place to start is with a good understanding of what you'll use it for. If you need scans, copies or faxes, you'll need to buy a multifunction peripheral (MFP). We'd generally recommend one anyway for a home or micro office, but if you only need to print, a single-function device might prove better value.

If you're buying for general use in the home, look no further than an inkjet MFP. These will handle prints, scans and basic copies, while you can pay more to get an automatic document feeder (ADF), which supports multi-page copies and scans. Most home-orientated devices will make a decent fist of text, graphics and even photos, although you'll only enjoy looking at your snaps if you use coated photo paper.

If you're buying for business, it's better to seek out an MFP with an ADF and fax modem. While few people still use it, fax is still useful in certain industries and regions. The presence of fax is also a sign that an MFP is focused more on office use. If it's an inkjet, it might use pigment inks (rather than dye-based inks), which produce better results on plain paper. It's also likely to be more durable.

For office work, the ideal printer is one with automatic duplex printing.

ABOVE If your printer will be used in a business environment, an MFP is your best bet

ABOVE Inkjets with refillable tanks are the most economical

By duplex, we simply mean that it prints on both sides. This saves paper, but it can also look more professional if you're producing reports or handouts. On an MFP, look for a duplexing ADF – this lets you make double-sided scans, prints, copies and faxes. The cheapest printers and MFPs have only one paper input, which can be a pain if you often print photos or use headed papers. Devices with two trays can save a bit of hassle.

Inks, tanks and toner

Conventional wisdom has it that inkjets are best for home printing and lasers for the office, but that's been turned on its head somewhat with the arrival of more durable inkjets. It's still true that laser printers are generally faster, and that they generally produce better black text. The best colour lasers also produce high-quality graphics on plain paper much more quickly than most inkjets.

Don't overlook inkjets for business use, however. While lasers do tend to be robust, it's a myth that they're necessarily cheaper to run. Inkjets with refillable tanks offer the cheapest cost per page, and they can go for a similarly long time without needing

PC PRO TECHNOLOGY EXCELLENCE AWARDS 2024: BEST PRINTER MANUFACTURER

	Customer support	Reliability	Value inc running costs	Print quality	Buy again?	Overall
Brother	81%	91%	89%	90%	98%	90%
Xerox	86%	90%	86%	93%	97%	90%
Epson	80%	88%	85%	88%	93%	87%
Canon	76%	84%	81%	86%	94%	84%
HP	73%	78%	77%	84%	83%	79%

How we test

We put every printer and MFP through a set of standard tests, designed to replicate real-world printing. These range from everyday text jobs to tortuous multi-page graphical prints – if a device has strengths and weaknesses, we'll quickly find them.

We start by setting up every device, connecting it to the internet where supported, and downloading any firmware updates we're offered. It's increasingly rare to get a CD in the box, so in most cases we download the full software package from the manufacturer's website, applying any other updates that come up. Once set up, we perform any alignment or nozzle checks if prompted, then print a set of documents designed to showcase basic text and graphical quality.

Print tests

This done, we break out the stopwatch and set about seeing how fast a printer can move. The first test is to time 25 identical pages of black text, recording the first-page out time, and calculating the overall speed in pages per minute (ppm). On inkjets, we'll repeat this test in draft or economy mode, and on lasers we'll repeat it after an hour of idling to get a "first page from cold" time. On office-focused devices we also print a 50-page text document, which gives faster printers a chance to get into their stride.

Next it's time to look at graphics performance, with a 24-page colour document comprising magazine pages, presentation slides and a set of ten web pages. It's a stern challenge, usually emerging far more slowly than the manufacturer's stated speed even on a mono printer, but it probes a device's ability across a range of subjects.

On double-sided printers, we also duplex the first ten pages of this document to calculate a speed in images per minute (ipm). Finally, we measure how long it takes to produce a first colour page, again repeating this test on laser printers once they've been idle for an hour.

Our final routine print tests look at photo speed and quality. On an inkjet we'll time how long it takes to print six 6 x 4in photos on glossy paper, without borders where available, and at the highest possible quality. On a laser we print three A4 pages containing the same images, again at the best quality available. We print two further A4 sheets containing 6 x 4in photos, again using the best quality settings, and coated paper on an inkjet. Finally, we time A4, A3 and A3+ borderless photos where possible, and print a sample black and white image.

Photocopy and scan tests

We're not finished yet with an MFP, on which we'll time single black and colour copies. If there's an ADF we'll also time ten copies, and if it supports duplex we'll time a 10-page, 20-side colour copy for good measure.

ABOVE We scan this Kodak reference image to test every MFP's scanner quality

Next, we'll note how long it takes to preview an A4 page, and to scan it at 150 and 300 dots per inch (dpi). We also scan a 6 x 4in photo at 600dpi and 1,200dpi (where available), and finally we'll use a Kodak Q60 colour target to test the scanner's colour accuracy and dynamic range. While we're working, we measure every printer's sleep, standby and peak power use, too.

You'll find the results of all our tests either in the feature table on p80 or the performance graphs on p94. And where a printer is particularly quick, slow, good or bad, we'll always talk about it in our review.

new consumables. Inkjets use less power, typically peaking below 30 watts, compared to several hundred watts for a laser. They're usually quicker to start printing, too, even if a laser might overtake them on longer jobs.

Better connected

It's important to consider how many people will need access to your printer or MFP. If it's only for you, a simple USB connection will be fine – although USB-only printers like the HP LaserJet M209d miss out on cloud-based features such as printing from a Google Drive.

If you're sharing your printer, we strongly recommend either wired or wireless networking. With modern routers and protocols, the latter is generally reliable in homes or offices, but it's worth checking the signal strength where you're planning to put the printer. On Android, you can use Ubiquiti's WiFiman, but Apple doesn't allow apps access to this information.

None of the printers in this group test has a memory card slot, but a few of them have a USB host port. This allows you to print from – and with MFPs, also scan to – an inserted thumb drive. That's a good way of ensuring confidentiality if you're printing out something like pay slips, but it's also a simple way to let office visitors print.

ABOVE A USB port means you can print from and scan to a thumb drive

While lasers do tend to be robust, it's a myth that they're necessarily cheaper to run than inkjets

Durability and reliability

If you're expecting to print in high volumes, or if you're buying a printer to go in a colleague's or relative's house, consider how often you'll need to change its consumables. Many printers in this test can go several thousand pages before needing attention, which could save you hassle if you're the only person who knows how to fit new toner or top up an ink tank.

This brings us to the subject of durability. In the feature comparison table on the previous page, we print a line that shows how many pages each printer is designed to print. This may be a maximum number per month or a recommended number, and sometimes there's a lifetime limit. Also note that a few laser printers include replaceable elements such as drums, so factor that into your pricing if you intend to use your printer for the long haul.

Regular readers will also know that we gather information about how satisfied people are with the brands they buy. We print this in our annual Excellence Awards (*see table, opposite, and issue 363, p28*). Brother has consistently been rated top for reliability, customer support and value for money (which includes running costs), so this should be part of your buying decision. Our reviews on the next pages, however, focus on the merits of individual products.

Epson EcoTank ET-2865

Much to like, from the refillable ink tanks and thus low running costs to decent prints, scans and copies

SCORE ★★★★☆

PRICE £194 (£233 inc VAT)
from uk.insight.com

ABOVE The ET-2865 comes with a clever refillable ink system

If you've ever owned an inkjet you've probably found yourself cursing short-lived cartridges, and the sheer cost of keeping the replacements coming. Refillable ink tank printers such as the Epson EcoTank ET-2865 and HP Smart Tank 7005 offer a promising answer. Although you'll spend more to buy the printer, you fill it with bottled ink without the big markup, letting you print high volumes without fear of a steep cost per page.

The ET-2865 arrives with a full set of Epson's 104 ink bottles. These are rated for up to 4,500 black and 7,500 colour pages, but you'll lose a large proportion of the first set to a one-time priming process. With an anticipated subsequent yield of 3,600 black and 6,500 colour pages, the supplied ink alone lasts about ten to 15 times as long as a typical "high-yield" inkjet cartridge. That makes the ET-2865 better value than many cartridge-based multifunctions even before you have to buy any ink.

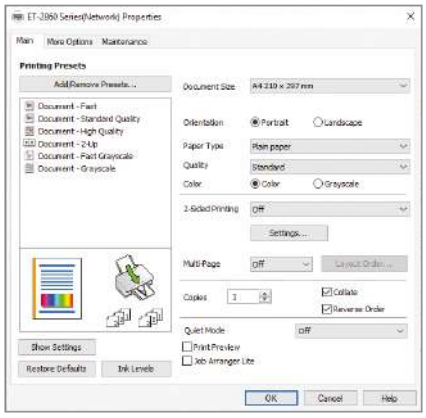
LEFT Filling the tanks is foolproof: you can't get it wrong

The flip side is that ink tank printers can be relatively basic, and that's certainly the case with the EcoTank ET-2865. While it's a three-in-one MFP supporting wireless networks, it doesn't support automatic double-sided printing, and there's no display for using more advanced features.

Epson's EcoTank system has been around for a while, and it's essentially foolproof: you simply upend each of the bottles onto its associated ink tank. We didn't get on so well with the comparatively new Smart Panel mobile app, used to configure the printer and get it onto your Wi-Fi network. This is designed to look like a chat session, and it's unnecessarily verbose – for example, giving you a lecture on what Wi-Fi passwords are, where you might find yours, and what characters it might contain when you already know all that and are impatient just to type it in. This makes it all the more annoying that it doesn't mention where you might find the printer's unique password; we had to open a few flaps before we got to that.

When it comes to print and copy speeds, the ET-2865 can't compete with similarly priced inkjet MFPs. Colour graphics inched out at just 2.7ppm. At 8.8ppm, text printing was slow in the default mode, but switching to draft almost doubled this to 15.3ppm. Unfortunately, it was very faint, so strictly for draft use only. We had a much longer wait for photo prints. Our two-page 10 x 8in photo test took an incredible 18 minutes, while each 6 x 4in borderless photo needed nearly three minutes to emerge. At 15 seconds, mono photocopies weren't too tardy, but each colour copy took 37 seconds.

Fortunately, there wasn't so long to wait for scans. The ET-2865 could capture an A4 document in 11 seconds, although this rose to 25 seconds at a more detailed 300dpi. Photo scans weren't much slower, with even a 1,200dpi capture completing in just under a minute.



BELOW With no screen, you'll see this dialog a lot

All this would be for nothing if the results weren't any good, but here the ET-2865 begins to be more impressive. It's a solid plain paper printer, producing reasonable text and colour graphics, although they lacked impact compared to the best plain-paper devices. It's also a fine, bordering on excellent photo printer, delivering extremely detailed black and white photos in particular. While a little lacking in detail in the lightest areas, it reproduced very accurate and convincing skin tones in portrait prints.

Our test unit had a fault that caused a black band in scans and copies, but we're confident this was a one-off issue. Outside this area, scans were good, if not the sharpest we've seen. Mono copies were a touch too dark by default, and colour copies a little soft.

Like most refillable printers, the ET-2865 really excels when it comes to running costs. Epson's 104 inks deliver a cost per page of only 0.5p, or 0.2p if you're solely printing in black. That makes for an almost unbeatable cost of ownership, but there's a caveat: refillable printers become better value the more you print, and you'd need to consume most of the bundled ink before the ET-2865 was a more sensible buy than a cheap cartridge-based alternative. Despite this, it only has a one-year warranty; if the printer fails between the warranty expiring and you running out of ink, you could be worse off.

JARGON BUSTER **ADF:** automatic document feeder, which sits atop a printer and feeds pages to be copied so you don't need to put them in manually. **All-in-one:** another name for an MFP, so it can print, scan and copy (and sometimes fax). **dpi:** dots per inch, the resolution at which scanners can capture images

HP OfficeJet Pro 9135e

Another Labs, another winning office inkjet from HP. We just wish it would calm down about cartridges

SCORE ✪✪✪✪✪
PRICE £161 (£193 inc VAT)
from printerbase.co.uk

HP's printer range can be hit and miss, but the US giant is pretty reliable when it comes to home office and micro-office inkjets. A case in point is the OfficeJet Pro 9135e, the latest mid-range, mid-size inkjet MFP to waltz across our desks. With a fairly steep price tag and a big, boxy design, it isn't courting impulse home buyers; this is an office workhorse, with a recommended monthly print volume of up to 2,000 pages.

The strong specification starts with paper handling. It has two 250-sheet cassettes, letting you stock up on a full ream of plain paper, or load headed or specialist media alongside plain. Automatic duplex printing is standard. On top you'll find a 35-page ADF that also supports duplexing, enabling double-sided scans and copies. HP throws in faxing for good measure.

The OfficeJet Pro 9135e connects to either wired or wireless networks. On its front panel there's a USB host port for scans to, or prints from, an inserted drive. The final thing of note is HP's customary lipless scanner platen, which makes it very easy to retrieve documents. We can't understand why other brands haven't copied it.

We're glad HP's rivals are more relaxed about software and cartridges, though. HP seems hell-bent on its HP Smart app, to the extent you have to actively seek out the conventional PC software package, bringing to mind Arthur Dent's struggles to find a planning application. Rather than helpfully guiding you through the cartridge installation, the 10.9cm colour touchscreen curtly directs you to the setup website. Throughout you're assailed by data agreements, reminders that third-party cartridges might not work, and sign-up pages for HP+.

If it's not a particularly welcoming start to life with the 9135e, things quickly get better. This is a rapid printer, which delivered our 25-page black text document at a laser-rivalling 22.1ppm. It was also unusually quick in colour, printing our challenging 24-page colour graphics test at 8ppm – right at the top end of what we'd expect from an inkjet. While duplex graphics weren't laser-quick, its 3.7 images per minute was again brisk by inkjet standards.

We still don't love HP's scan software, which is oversimplified for our tastes, and which doesn't have an auto detect feature for the scan area. Still, the OfficeJet Pro 9135e proved a rapid scanner, completing a preview scan in only seven seconds – no further scanning is necessary to capture an image at resolutions up to 300 dots per inch. This scanner was quick in high-resolution scans of a 6 x 4in photo, completing a 600dpi capture in seven seconds, and needing only 21 seconds at 1,200dpi.

The 9135e continued to demonstrate its office chops when it came to photocopying. It completed a one-page mono copy in eight seconds and a colour copy in 11 seconds. Using the ADF, ten-page copies completed in 50 and 74 seconds respectively. Impressively, the ADF uses two sensors rather than mechanical duplexing, so a ten-page, 20-side copy was completed in just over four minutes.

ABOVE Two paper trays, an ADF and duplex – the 9135e excels at office tasks

LEFT HP's newer touchscreen menus seem less friendly than before

There's not much to complain about when it comes to quality. This MFP produced excellent, laser-rivalling black text, but plain paper graphical prints were less authoritative than we would expect; they were free of obvious banding or other inkjet vices, though. Mono copies were excellent, as was the exposure on colour copies, although these suffered from desaturated colours. Even photos were satisfactory for occasional prints. We've complained before about HP scanners that seem to digitally sharpen the image, whether you want it or not. This issue aside, scan quality was more than good enough for any office application.

Fortunately, HP hasn't dropped the ball when it comes to ink costs. The 9135e comfortably made it through our tests on its starter cartridges. When they're empty, high-capacity replacements work out at 2p per black page or 6p for colour – not the lowest, but acceptable for moderate use. This is the part where we usually mention that you can pay less if you sign up for HP's Instant Ink service, but a price increase means the lowest rate per page is now 3p; if you mostly print in black, buying your own cartridges is likely to work out cheaper.

Overall, aspects of using and owning the OfficeJet Pro 9135e could be annoying. Look beyond them, and it's an excellent device.

JARGON BUSTER **Duplex:** double-sided printouts; automatic duplex means you don't need to turn over the pages yourself. **Duty cycle:** the maximum number of pages that a printer is designed to cope with in a given amount of time, usually a month, without affecting wear and tear.

Canon Pixma TR7650

Canon's Pixma TR7650 isn't sure whether it belongs in the home or an office. Luckily, it will be fine in either

SCORE ★★★☆☆

PRICE £151 (£181 inc VAT)
from printerbase.co.uk

Canon's Pixma TR7650 is something of an oddity. It's clearly geared up for a home office, with business-like features such as a 20-sheet ADF, two paper trays, automatic duplex (double-sided) printing and a fax modem. At the same time, it's equipped with five individual ink cartridges, which together help it excel on plain paper, while still delivering good photos and graphics.

Whatever you want it for, the TR7560 is well equipped for the job. It supports wireless networking, so you can share it among colleagues or family members. It's also controlled by a large colour touchscreen, offering features such as printing from the cloud or scanning to it. Despite its generous specifications, it's not overly big, especially if you don't often use its rear paper feed, which can fold away entirely.

ABOVE The Pixma TR7650 is a compact inkjet MFP that will suit a home or office

The Pixma TR7650's five ink cartridges aren't keyed to prevent you putting them in the wrong slot, although the printer will only prime itself once they're all in the right place. While the physical design of Canon's single-ink cartridges hasn't changed significantly in years, for some reason this time they were more prone to dripping on our hands and desktop.

We found a few other minor irritations, too. The default control beep is needlessly loud, and the control panel fouls the paper output unless you pull it almost fully upwards and flat. The touchscreen is so heavily recessed that it can be tricky to interact near its edges. And finally, while it's great that this multifunction can do a multi-page, double-sided copy, you need to enable duplex printing and scanning separately, rather than having one simple "2-2" option.

BELOW You can print from the cloud

Fortunately, there's nothing much to criticise about the quality of the results. The TR7650 has an excellent scanner, delivering sharp images with great colour accuracy and an impressive dynamic range. It's also a good copier, particularly for black-only prints. With four dye-based inks, it's a capable photo printer, producing sharp snaps with a slight tendency towards oversaturation. And with a large pigment black ink cartridge, it also produces impressive text.

It's a shame, then, that this isn't an especially cheap device, and it's also pricey to run. At 2.9p per page, black prints in particular aren't competitive, even for an inkjet. This isn't a bad device for the home, but for a home office, HP's OfficeJet Pro 9135e is much better.

Epson WorkForce Pro WF-C4310DW

A single-function inkjet that doesn't quite tick all the boxes, so we'd choose one of its rivals instead

SCORE ★★★☆☆

PRICE £96 (£115 inc VAT)
from printerland.co.uk

Not everyone needs a multifunction peripheral: Epson's WorkForce Pro WF-C4310DW focuses on printing. It's a cartridge-based device, offering a cheaper alternative to refillable single-functions such as Canon's Maxify GX5550 (*see issue 353, p89*). Although it doesn't have much in the way of bells and whistles, it does support automatic double-sided (duplex) printing, along with wired and wireless networking.

Superficially, then, this printer has everything the home office might need if you're just looking for a single-function device. It comes with a decent 250-sheet input cassette, and is even rated for a one-off monthly duty cycle of 33,000 pages. It's relatively light and compact, too.

ABOVE Epson's WF-C4310DW is an inkjet printer aimed at micro offices

Start printing and the WorkForce Pro WF-C4310DW is quick to impress. It churned out our 25-page mono text test at a rapid 19.7ppm – about the same rate as an entry-level laser. Predictably for an inkjet, colour graphics were much slower, but at 5.4ppm they still compared well to others in this class. It reached a creditable three images per minute when duplex printing colour graphics – not bad for an inkjet.

As it's equipped with pigment-based inks best suited to plain paper printing, the WF-C4310DW isn't really a photo printer, but it will give it a go. It took more than eight minutes to print two 10 x 8in photos on A4 paper, and needed more than 15 minutes for six borderless, postcard-sized photos. Pigment inks can't fully penetrate glossy photo papers, so while the results had good colour accuracy, they had a characteristic semi-matte finish.

Unfortunately, this printer didn't excel on plain paper, either. Its black text wasn't as dark as the best, and colour graphics were a little on the faint side with some banding. There were even a couple of subtle ink smears on our presentation slides.

RIGHT There are few bells and whistles, but it can be networked

Just as importantly, the WF-C4310DW isn't especially cheap to run. Even sticking to large cartridges, you'll pay around 1.7p per black page, and a whopping 11.7p in colour. That's at odds with this printer's decent paper capacity, speed and comparatively high duty cycle, and makes it suitable only for those who mainly print black pages. If you print lots of colour, or in higher volumes, consider the Maxify GX5550 instead.

Epson WorkForce WF-2960DWF

This cheap multifunction peripheral has its moments, but despite the low price it's not great value overall

SCORE ★★☆☆☆

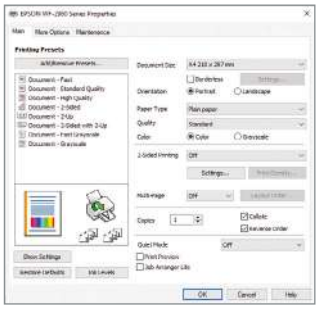
PRICE £67 (£80 inc VAT)
from printerland.co.uk

At first glance, Epson's Workforce WF-2960DWF looks like great value. It's an inkjet multifunction peripheral offering prints, scans, copies and fax, and all for £80. It's well specified, too, with a colour touchscreen, automatic duplex printing and a 30-sheet ADF to help make light work of multi-page scans, copies and faxes. It supports both wired and wireless networks, too.

So it seems there's not much to count against it. The WF-2960DWF is fairly rapid for the price, managing to produce our 25-page text test at 14ppm. With the print quality lowered to draft, it even hit an impressive 18.8ppm. Colour graphics printed at a competitive 4.9ppm, and a duplex colour job progressed at three images per minute – not as slow as it sounds.

ABOVE Epson's WF-2960DWF isn't the bargain it seems

As we'd expect from Epson, this MFP has a good scanner. While a touch soft when capturing photos, it excelled with great colour reproduction and a wide dynamic range, helping preserve detail from among the lightest and darkest shades. Photocopies were also decent, although black-only copies were a shade too dark.



RIGHT You'll find yourself checking the ink supply levels regularly on this printer

Unfortunately, things started to come undone when the supplied ink ran out during our ten-page colour copying job, by which point this MFP had printed only about 100 pages, with roughly 35 of them in colour. That suggests a shockingly low amount of starter ink, which might go some way to explaining this printer's "bargain" price.

Equipped with replacements, we completed our tests with slightly underwhelming results. Photo prints were good, save for a lack of contrast among the darkest shades. Duplex graphics were too faint, the result of the printer using less ink to prevent smearing. Worst of all was normal quality black text that looked so faint we initially mistook it for draft.

We'd be happy to overlook much of this at this price if comparatively high ink prices didn't put the boot in. Stick to the XL replacements and you'll pay around 14.4p for each full-colour page, of which the black component works out at 3.6p. That's too much. Unless you barely ever print, pay the extra for a more highly specified rival such as the HP OfficeJet Pro 9135e.

HP Smart Tank 7005

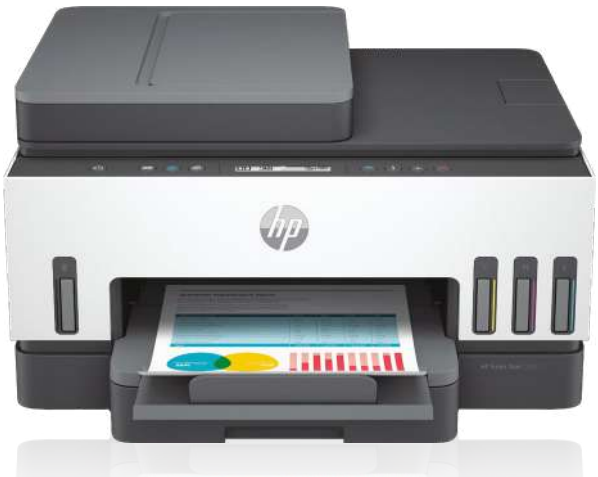
A great-value refillable multifunction peripheral that's let down by its poor scan quality

SCORE ★★★☆☆

PRICE £183 (£220 inc VAT)
from amazon.co.uk

HP's Smart Tank 7005 is a home office MFP with refillable ink tanks rather than cartridges. Typically for an ink tank printer, it's basic despite its high price. There's no screen here, but there is a single-line mono display and automatic double-sided printing, which gives it an advantage over Epson's pricier EcoTank ET-2865. This printer also has a three-year warranty, although you need to register to activate it.

Like other refillable printers, the high initial cost is offset by extremely cheap ink. The Smart Tank 7005 arrives with two black bottles and a full set of colour inks that should last for around 8,000 colour pages, or a mighty 12,000 black prints. Unlike some competitors, the 7005 is pre-charged with ink, so you shouldn't lose many pages to the initial priming of the system. When the supplied ink runs out, you'll pay only 0.1p per black page and 0.3p for colour – magnificent.



ABOVE This is a straightforward, boxy-looking MFP

Here, there's a slightly more involved setup than with the ET-2865. You'll need to fit the print heads and top up the tanks with ink, remembering that HP's system doesn't prevent you accidentally mixing up the colours.

RIGHT We love the lipless scanner platen, less so the unkeyed colour tanks

Software setup comes courtesy of the HP Smart app, which can be frustratingly slow. If you want a full PC driver set, you'll need to search for HP Easy Start.

This is a decently brisk text printer, serving up 13 pages of black text per minute. It's more ponderous over graphics, reaching 3.6ppm, or 2.2 images per minute when duplexing. Scans weren't especially snappy at higher resolutions, with our 1,200dpi postcard photo needing two-and-a-half minutes. At 18 seconds in black and 27 seconds in colour, photocopies were leisurely, too.

The Smart Tank 7005's print quality was a mixed bag, ranging from excellent black text to photos with an orangey bias. Colour graphics were fairly good, as were photocopies. What a shame, then, that this MFP's scans were disappointing. Photos showed signs of unwanted digital sharpening, while our lower-resolution document scans bore what looked like compression artefacts. That's not something we've seen before, and it didn't help the legibility of smaller fonts. Although this is a decent MFP overall, its good value doesn't fully make up for its shortcomings.

Canon i-Sensys LBP243dw

Fast, high-quality prints and low running costs, this is everything you'd want from a mono laser printer

SCORE ★★★★★

PRICE £155 (£186 inc VAT)
from printerbase.co.uk

ABOVE It's aimed at businesses, but the LBP243dw isn't too big for a small home office

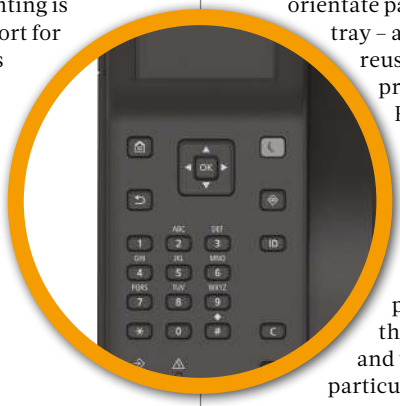
It's hard to get excited about a mono laser printer, but Canon's i-Sensys LBP243dw gives you more reason than most. Inside its compact and unremarkable shell lurks a truly capable printer that's extremely well suited to busy small and micro businesses.

For the money, the LBP243dw offers a reasonable specification. It combines a 250-sheet cassette with a 100-page multipurpose (MP) feed, making it more flexible than cheaper laser printers with only a single-sheet MP slot. Duplex printing is standard, as is support for Wi-Fi networks. It's also good to see a gigabit Ethernet port, although for printers we're not convinced it offers much advantage over Fast Ethernet (100Mbits/sec).

This printer doesn't have the colour touchscreen you'll find on more expensive rivals, but its five-line mono display makes control easier than on more rudimentary devices. In particular, it's comparatively easy to enter a wireless password, which can be a nightmare on text-only systems. It's a shame this isn't paired with a USB host port, but perhaps not surprising at this price. Canon doesn't sell much in the way of upgrades for the LBP243dw, but you can increase its paper capacity to 900 sheets with an optional 550-sheet cassette.

This is one of the few printers to still arrive with a driver disc in the box, although it's also easy to find Canon's Master Setup program online. You'll need to extend the paper cassette before it accepts A4 paper, after which you'll find it juts slightly from the rear of the printer when inserted. Happily, Canon has fitted a flap to prevent the top sheet being exposed to dust.

On the flip side, this might be the only printer we've ever seen where there's no mark to show you how to orientate paper in the main tray – a pain if you're reusing paper already printed on one side. For reference, the LBP243dw prints on the underside of paper in the cassette. You're welcome.



LEFT The printer's controls are very clear and easy to use

Mono laser printers are usually the fastest we test, and the LBP243dw was particularly keen to get going. It could deliver a first page of text in seven seconds, needing only one extra second when starting up from cold. It hit an impressive 32.6ppm over our 25-page text test, which includes the time taken to spool the job. We retested this printer with a 50-page document, over which its speed edged up to 33ppm – not far short of its rated 36ppm speed.

The i-Sensys LBP243dw wasn't quite so impressive when faced with our complex graphics test, which it completed at a best rate of 21.5ppm. Our first attempt at this job was interrupted by a brief housekeeping pause, which lowered this to 20ppm. Despite not being especially quick on the graphical pages we use for our test, this was a very competitive printer when duplexing, managing 14.6 images per minute – the second fastest in this group.

PC PRO LABS WINNER LASERS

Most people buy mono laser printers for fast and reliable text, and the good news is that the i-Sensys LBP243dw doesn't disappoint. It produced exceptionally good black text, with extremely fine character outlines filled with bold black.

Few people expect great graphics from a laser, but here the LBP243dw is a welcome surprise. It's one of the best mono lasers we've tested for graphics quality, with no banding and barely visible dither patterns (used to create different shades). With excellent shading control and accurate exposure, photos and business graphics were far better than the average.

There's a final – and important – piece of good news. This printer arrives with only a 1,500-page starter toner, but you can replace it with a high-capacity cartridge that's good for 10,200 pages. It's the only consumable, combining drum and toner, which means you get an impressively long service interval for this class. Even better, it works out at a very reasonable 1.2p per page, making this a cheap laser to run.

Canon says this printer has a 80,000-page lifetime duty cycle, with a recommended monthly volume of up to 4,000 pages. That makes it well suited to a busy home office. Adding the optional 500-page tray would help it grow with an expanding small business. It's certainly a printer you'll want to keep, combining fast text, excellent print quality and low print costs in a near perfect package.

JARGON BUSTER **ipm:** images per minute, a measure of speed that includes text, graphics and images that we use to compare duplex printout speeds. **MFP:** multifunction peripheral, so will always include a scanner as well as a printer (so they can also photocopy). Some MFPs also include a fax. **ppm:** pages per minute.

Kyocera Ecosys PA4000wx

A fast mono laser printer combining decent quality with impressively low running costs

SCORE ★★★★☆

PRICE £275 (£330 inc VAT)
from printerbase.co.uk

ABOVE Kyocera's printers are unapologetically business-focused

Kyocera's Ecosys PA4000wx is primarily aimed at small workgroups and offices rather than home users, but it's compact enough to fit in most home and micro business scenarios. It's a single-function mono laser printer with high specifications, not least of which is a claimed 40ppm engine speed.

As you can probably guess, the "W" in this printer's name confirms it has wireless networking. It supports standards up to 802.11ac (Wi-Fi 5), which should ensure fast and robust connections, but you can use the gigabit Ethernet port if you prefer. In the base you'll find a 250-sheet input cassette, while its front panel has a 100-page multipurpose feed; a boon if you often print on headed paper or special media. Automatic double-sided printing is available when you want it, and there's a USB host port for walk-up prints.

LEFT The basic display is enough to help you use the USB host port

Manufacturers talk a lot of rot about sustainability, but Kyocera's Ecosys range has more credibility than most. The PA4000wx has a ceramic drum that, in normal use, is expected to last the lifetime of the printer. That cuts down on consumables, and hence waste. It's also boxed using cardboard padding, so it's a shame to find the printer itself in a big plastic bag. There's not much other packaging to remove; you just need to pull off some tape and lock the toner in place.

We haven't previously had any problems with Kyocera's software, but in this test the setup program wasn't able to install all the available drivers in the virtual machine we use for testing. Only one of the drivers failed when we attempted the install on our host PC, however. We couldn't get to the root of the problem, but we installed and used the PCL mini driver without further issue.

With no drum or other consumables, this printer's service intervals are long. The PA4000wx arrives with a decent 3,600-page starter toner, but its replacement is rated for 10,000 pages, which might equate to a year or more of moderate use. If you're buying for business, this could make this printer a low-maintenance device for home workers.

In the office, the PA4000wx can cope with a monthly workout of 2,000 pages or an 80,000-page maximum. Kyocera states a robust expected life of 200,000 pages, or five years' use. Although the standard guarantee period is two years, the drum itself is covered for three. If your printing needs do grow, you can expand this printer with up to another two 250-sheet paper feeders, for an 850-sheet total.

That's all very promising, so it's a relief to discover that this is a good printer in practice. It's quick off the mark, delivering a first page of text just 13 seconds after we clicked Print. It only needed a further second when waking up from cold. The PA4000wx reached a brisk 31.3ppm over 25 pages of text. Unusually, at 32ppm it was slightly faster on our challenging graphics test. It also managed the fastest duplex performance in this group of printers, reaching 15.4 images per minute over ten sides.

We give faster printers the chance to stretch their legs over a longer 50-page print job, on which the time taken to spool the job has less of a bearing. On this the PA4000wx hit 36.6ppm, close to its stated maximum.

In the past we've often been disappointed by a slight softness to prints from Kyocera printers. Happily, the PA4000wx didn't have this issue, producing uniformly dark text with crisp outlines. Its graphical prints were quite good, too, demonstrating better shade control and less obvious dithering than most. Some photos showed banding, and many were a shade too dark, but overall this printer did a good job by mono laser standards.

There's a final reason to like the Ecosys PA4000wx. Its 10,000-page toner is priced at only 1.1p per page, giving it competitive print costs, especially when compared to similarly priced colour devices. Overall, it's a very capable small business printer, combining high speeds with good quality and low running costs. We would have given it a fifth star if Canon's i-Sensys LBP243dw didn't cost quite a bit less and run it very close in most regards.

JARGON BUSTER

Multipurpose feed: a tray that allows different sizes and types of paper/media to be fed in, as opposed to standard A3 or A4 paper in the main tray(s). **Platen:** the scanning surface of a scanner. **TWAIN:** technology without an interesting name (yes, really). A protocol that helps apps control scanners.

Brother HL-L2865DW

A great mono laser if you churn out text, but it's let down by poor graphical prints

SCORE ★★★☆☆

PRICE £94 (£113 inc VAT)
from printerland.co.uk

For all the appeal of the best inkjets, it's hard to top a straightforward mono laser printer if you plan to print a lot of text. Brother's HL-L2865DW is an entry-level option, but it still offers a few useful features, including wired and wireless networking, as well as automatic duplex printing as standard.

This printer has a 250-sheet paper cassette, with a single-sheet bypass slot – useful if you want to start a job on headed paper. There's also a basic mono LCD screen, which makes it fiddly – but not unreasonably so – to enter a Wi-Fi password manually. While it's easy to set up Brother's software, you'll need the printer's password to update its firmware. Annoyingly, this is printed on the back panel and contains the full range of mixed-case letters and other characters.

ABOVE Brother's HL-L2865DW isn't a bad choice for text printing

Otherwise, the HL-L2865DW is easy to use. It's not the quickest printer to spring into action, needing 15 seconds to print a first page, or 22 seconds when doing so from a cold start. It's fast once up and running, though, hitting 26.8ppm over 25 pages of text. It also managed a rapid 24.8ppm performance when churning out detailed graphical prints.

RIGHT The 250-sheet paper tray has a single-sheet bypass slot

The HL-L2865DW has a claimed maximum resolution of 1,200dpi, but we weren't so sure. It's typical for lasers to print at half the speed when you double the print detail, but this one chucked out two 10 x 8in prints in 26 seconds and six postcard-sized photos on three A4 sheets in 30 seconds.

Regardless, this isn't a great choice if you plan to print lots of graphics. Our test results were uniformly too dark, with obvious banding running across the page. The printer didn't show great shade control, either, with smooth progressions rendered in distinct steps. Graphics aren't usually a mono laser's forte, but this one was especially lacking.

Happily, the HL-L2865DW printed excellent text. It has reasonable running costs for this class, with each page coming in at 1.8p. That makes it a decent choice if you print a reasonable amount of good-quality text. But if you want good graphics, look elsewhere.

Brother MFC-L2980DW

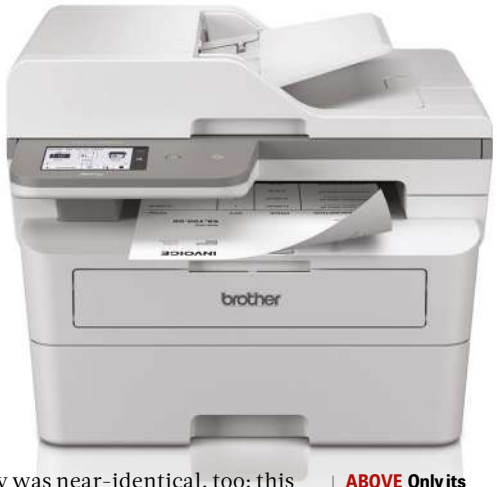
An MFP version of Brother's HL-L2865DW laser printer above. We're not sure it's worth the premium

SCORE ★★★☆☆

PRICE £268 (£322 inc VAT)
from printerland.co.uk

Brother's MFC-L2980DW is a compact mono laser multifunction peripheral aimed at small and home offices. Its top-heavy design pairs a laser printer with an A4 scanner and ADF. Both the printer and scanner support duplexing, so you can make double-sided prints, scans, copies and faxes. Everything's controlled via an 8.8cm colour touchscreen, although there's no USB host port for walk-up prints and scans.

This MFP's printer is essentially identical to the Brother HL-L2865DW. Unsurprisingly, then, its print speed results were almost the same, save for slightly faster duplexing, at 11.5 images per minute. The output quality was near-identical, too: this printer produced wonderful black text but, while graphics suffered slightly less from banding, they were still too dark.



ABOVE Only its mother could love this MFP's top-heavy looks

The similarity at the core of this MFP throws its price into sharp relief. You're paying almost three times as much to add scan, copy and fax functionality, so you'd want the extra functions to be worth having. We're not sure that they are.

At least there's not much wrong with the MFC-L2980DW's scanner. It could return a preview image in 13 seconds, and needed a mere 15 seconds to capture an A4 sheet at up to 300dpi. It only became slow at 1,200dpi, completing a 6 x 4in photo scan in 74 seconds. The results weren't the sharpest we've seen, but they were otherwise well exposed across all but the very darkest shades.

RIGHT The large touchscreen helps make this an easy MFP to use

This MFP's ADF supports duplex scanning in a single pass, paving the way for fast two-sided scans and copies. We timed a single black page at eight seconds, with a single-sided ten-page scan needing 34 seconds. A double-sided 10-page, 20-side copy completed in a minute and a half. Unfortunately, photocopies were all too dark, with subtleties of the original source often lost in translation.

The MFC-L2980DW uses the same consumables and has identical running costs to its single-function sibling, but they become less competitive when the device itself isn't as affordable. While the MFC-L2980DW is fine if you'll mostly work with text documents, it's not a great choice for graphical prints or copies, and will get expensive to run if heavily used.

HP Color LaserJet Pro MFP 3302fdw

HP's MFP 3302fdw produces fine prints, scans and copies, but it's a little slow and expensive to run

SCORE ★★★★☆

PRICE £292 (£350 inc VAT) from printerbase.co.uk

HP's Color LaserJet Pro MFP 3302fdw narrowly wins the longest printer name award for this Labs, but in the flesh it's surprisingly compact for a colour laser MFP. It takes up barely any more desk space than the OfficeJet Pro 9135e, its inkjet sibling, and is only slightly taller thanks to a thicker, 50-sheet ADF on top.

This is an impressively specified multifunction for the price. Both its printer and ADF support duplex operation, so you can make multi-page, double-sided prints, scans, copies or faxes without lifting a finger. You can connect it via gigabit Ethernet or 802.11ac Wi-Fi 5, and you even get a three-year exchange warranty provided you remember to register.

ABOVE This is a surprisingly compact MFP given everything it packs in

The MFP 3302fdw isn't in much of a hurry when it comes to printing. It needed around 20 seconds to dispense the first page of black text or colour graphics and – unusually for HP – an additional six to 12 seconds when waking up from cold. It went on to reach 18.5ppm when printing text, and 13.1ppm on colour graphics – both some way short of the stated 25ppm engine speed.

RIGHT You'll be replacing the toner more than you would on other lasers

It's a faster copier, completing a single mono page in ten seconds and colour in 14 seconds, and taking 41 and 76 seconds over the equivalent ten-page copies. It finished a 20-side, ten-page colour copy in a reasonable 98 seconds. Scans were very brisk up to a detailed 600dpi, but our 1,200dpi postcard photo scan needed 70 seconds.

We were delighted with this printer's excellent text and near-flawless colour graphics. Photos were often excellent, too, although some were spoiled by an overly blue colour bias. Mono copy quality was brilliant, while colour copies were well exposed if a little desaturated. Scans were fine for office work, although photo scans showed signs of digital sharpening.

So far, so good, but the MFP 3302fdw was let down by an at-times clunky user experience. Its print driver was often slow to respond, and HP's new touchscreen menu is a step backwards. It's also a bit expensive to run, with each black page weighing in at 2p. That, along with relaxed print speeds, is enough to take some of the shine off, but this is still a strong multifunction peripheral overall.

HP LaserJet M209d

The LaserJet M209d is about as basic as mono printers get – and there's no "but" to soften the blow

SCORE ★★☆☆☆

PRICE £100 (£120 inc VAT) from hp.co.uk

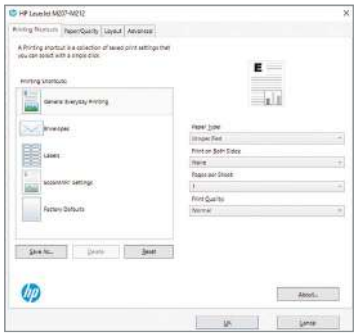
It's rare in 2025 to find a printer without wireless networking, and it's even more surprising to find a business device with no networking at all. HP's LaserJet M209d instead concentrates on delivering speedy mono output – up to a stated 29ppm – with automatic duplex printing, and literally no other notable features.

The printer connects to a single computer via USB. You could use Windows printer sharing, or some home routers or network-attached storage (NAS) drives to share it among many people, but the printer is designed for a single user who wants to print a lot of text.

It's a compact device despite a paper input that sticks out about 15cm from the front, so it's easy to find room for it on a desk. This is helped by input and output trays that are both easily reached from the front, so you could put it below an overhanging shelf.

ABOVE The M209d is the most compact printer in our group test this month

The M209d is as rapid as you'd hope when printing text. Regardless of when it had last been used, it could wake up and spit out a first page within seven seconds. It went on to hit 26.3ppm over 25 pages – an impressive result given our test includes the time taken to spool the print job itself.



RIGHT Features are about as basic as you can possibly get

Graphical prints were slower, with the printer reaching only 18.5ppm on our challenging test. We use the same document for our ten-side duplex test, on which the M209d managed a fair 9.4 images per minute.

As you'd hope, the LaserJet M209d produced strong text with crisp outlines, but its graphical output was very disappointing. Our black and white photo emerged from the printer much too dark, and all photos were somewhat too dingy. Most graphics looked oddly enhanced, as though the printer had tried to boost their contrast, leaving them looking like a cartoonish version of the original. This was most noticeable on a female portrait, where the subject's features were clownishly exaggerated as though by stage makeup.

We've got nothing against basic printers, but it's hard to make the case for the M209d given that it's not brilliant, and also not especially cheap to run at 2.2p per page. Canon's i-Sensys LBP243dw costs about 50% more to buy, but it's in another league.

Lexmark MS331dn

Lexmark's compact mono laser is a decent all-rounder, but it's not up there with the best

SCORE ★★★☆☆

PRICE £135 (£162 inc VAT)
from printerbase.co.uk

If you want a small mono laser for your office, Lexmark's MS331dn looks like a fine candidate. With a 38ppm engine, it promises a healthy turn of speed, particularly given it's affordable at well under £150.

If you're au fait with printer naming conventions, you'll know that the "D" in this model means it has automatic duplex printing. The "N" reveals there's also a network port, although this model doesn't support Wi-Fi networks – you'll need the MS331dw for that, which costs about another £35. Wired networking is good enough for most offices, although having Wi-Fi leaves you with more flexibility in where you put a printer.

ABOVE The MS331dn's business-like looks are improved by the paper tray's subtle swoop

The MS331dn is well specified for the price. It combines a 250-sheet input cassette with a 100-sheet multipurpose tray. Like many American printers, you'll need to extend its main paper tray to load A4 paper, which is longer than the Letter format used in the US. This leaves the back of the tray sticking out of the printer's rear, and unfortunately there's no cover to prevent it attracting dust.

RIGHT The small display is fine for everyday printer admin

We quickly discovered that the M331dn is rapid when printing text. It delivered a first page in 12 seconds, before going on to deliver a 28.8ppm performance over our standard 25-page document. We tried it on a 50-page document, expecting a faster time, but here the slight curl to printed pages made the printer think its 150-sheet output bin was full after fewer than 30 pages. We had to empty it twice to complete the job. At just 11.9ppm on our demanding graphical test, this printer struggled to keep up the pace when printing a mix of web, magazine pages and presentation slides.

That's a shame, as the MS331dn produced good-quality prints all round, despite a fair deal of banding on photos. Graphics were particularly strong, with subtle shade control reproducing a lot of detail.

Ultimately, this is a decent printer. However, despite the availability of a huge 15,000-page toner, it's considerably more expensive to run than the otherwise similar and Labs-winning Canon i-Sensys LBP243dw. That printer offers even faster speeds and better print quality, so it's the better buy overall.

Xerox C410

The competent C410 is a return to form from Xerox but falls short of the award-winners' podium

SCORE ★★★☆☆

PRICE £343 (£412 inc VAT)
from printerbase.co.uk

We've reviewed a couple of disappointing small office printers from Xerox in recent years, a stark contrast with its previous track record of excellence. We were anxious to see if the C410 would represent a return to form. It's a single-function colour laser aimed at busy small offices or workgroups. While it's a larger than rivals this month, it should squeeze into most home and micro offices.

This printer is rated at 40ppm in black or colour, with a 1,200dpi maximum resolution. It's equipped with automatic double-sided printing and a gigabit Ethernet port, but no wireless network interface in the "DN" specification tested here. While

ABOVE The C410 is a little bigger than most entry-level colour laser printers

a 250-sheet paper cassette is almost standard issue at this price, it's a shame to see a single-page multipurpose slot rather than a more versatile tray.

This printer is controlled with a large colour touchscreen, which helps with everyday admin functions. It's also a boon if you're using the front panel USB host port, which supports walk-up printing from an inserted drive. Unfortunately, it was a little slow to respond during the initial setup: an ill-advised repeated tap resulted in us accidentally selecting the Finnish language, which was quite a *päänsärky* to undo.

RIGHT Features include automatic duplex printing and a 1GbE port

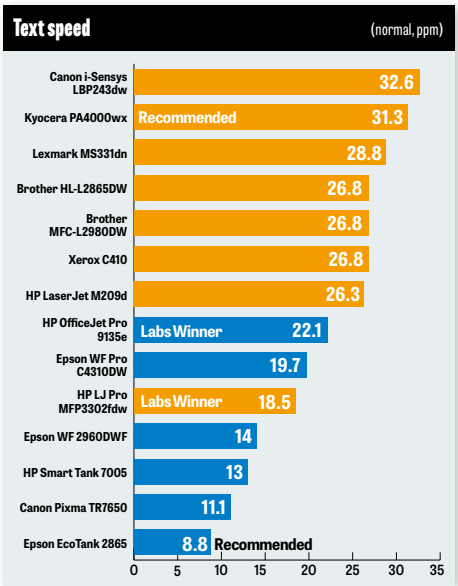
Like many other US printers, this one is designed for Letter paper, which is shorter than A4. Not only must you extend its main paper tray, which pokes uncovered from the rear, you need to slide the stop backwards in the paper output tray – miss that and things quickly get very untidy.

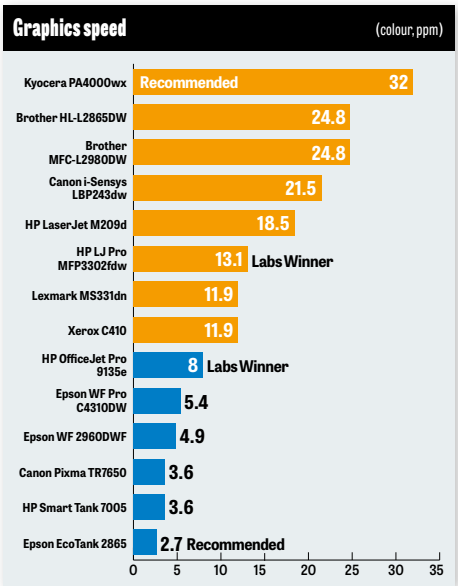
This was a reasonably quick text printer, reaching 26.8ppm on our standard 25-page test, and 28ppm over 50 pages. It reached only 11.9ppm on our challenging colour graphics test, though, with all these results falling some way short of the claimed 40ppm. Text print quality was good, but graphics and photos suffered from a warm, brick-coloured bias most notable on a brown presentation slide and on skin tones, where portrait sitters were given a peachy workover.

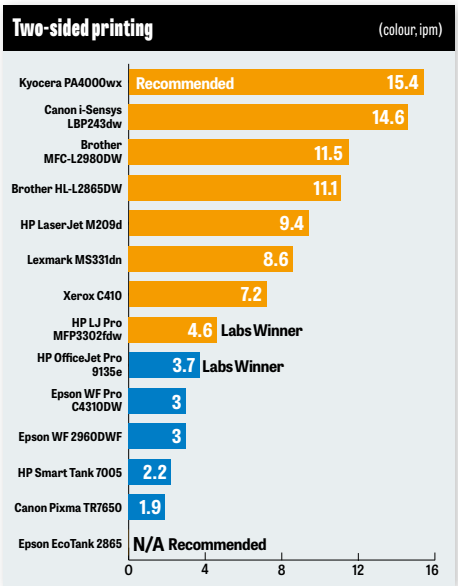
The relaxed performance and underwhelming graphics are a shame, because the C410 has reasonable running costs of 1.4p per black page and 7.8p for colour. This makes it hard to recommend when rivals such as HP's Color LaserJet Pro MFP 3302fdw do more for less.

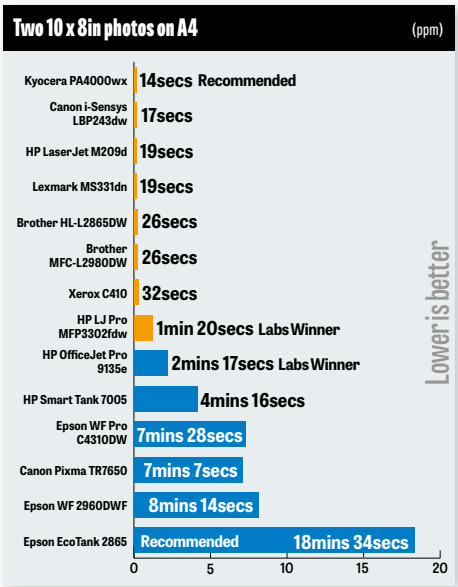
Print speed tests

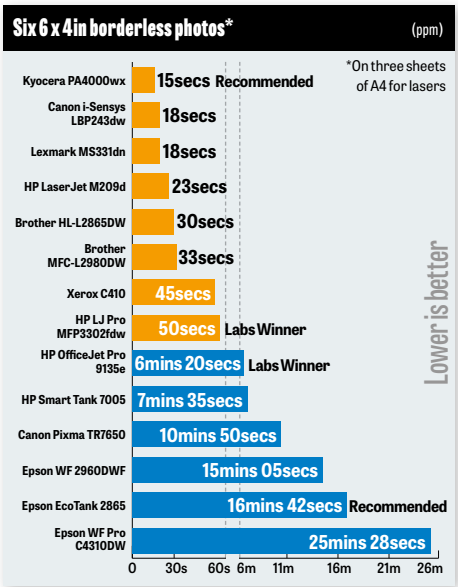
Inkjet printer Laser printer

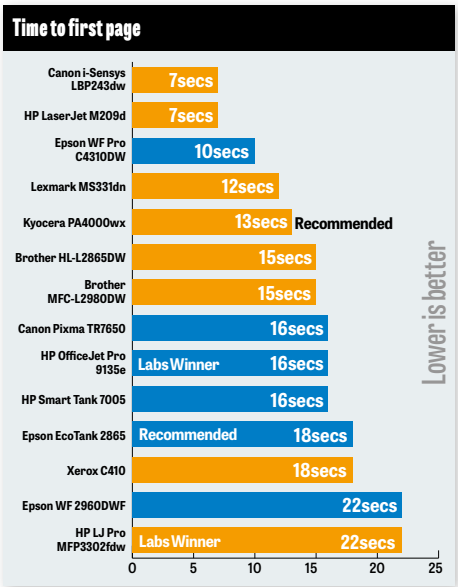




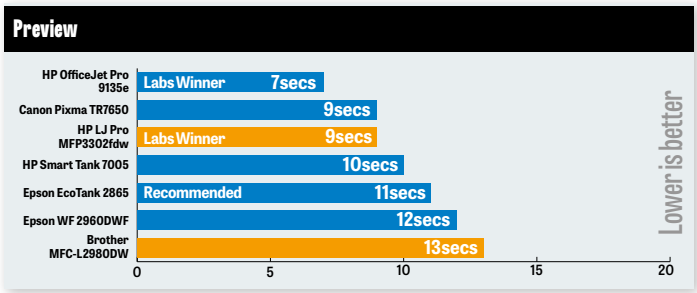


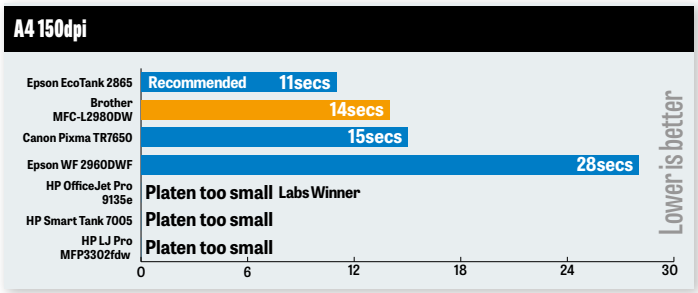


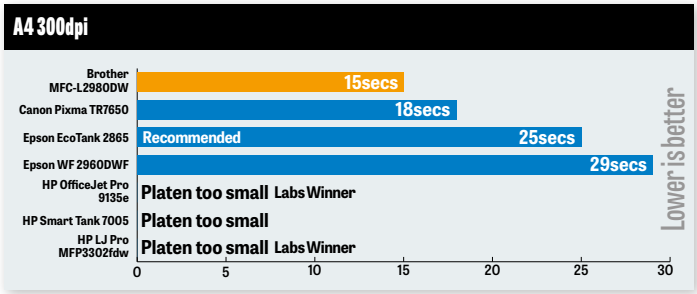


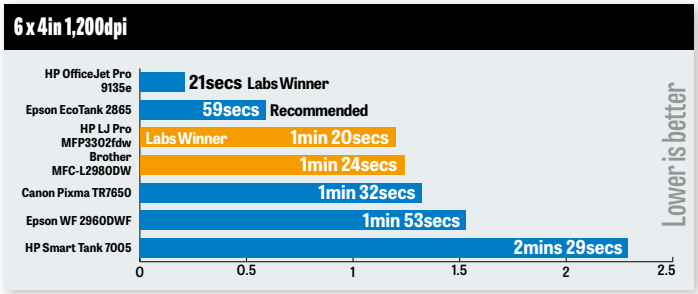


Scanning tests









View from the Labs

Much has improved in the two decades that Simon has spent testing printers, but the testing process brings more frowns than smiles

Forgive the self-indulgence, but it's 20 years since I first inserted a printer's driver CD, connected its USB cable, and hit it with a suite of demanding tests. That sentence alone tells you quite how much has changed. These days there's rarely a disc in the box – my test PC doesn't even have an optical drive – and virtually every printer comes with some kind of network interface.

While colleagues have gone on to review more glamorous devices, I'm still here, timing print runs, measuring power consumption, and poring over the fine print with an eyeglass inherited from an old art editor. I've reviewed several hundred printers, in which time I must have printed at least 50,000 sheets of paper. My *Computer Shopper* leaving cover pointed out the contrast between my "tree-hugging" beliefs and the forest-killing reality. And that was in 2007.

Little changes in the world of printers, but in this test I found myself thinking not about new technology, but about the strange backward steps manufacturers sometimes take. This was triggered by HP's new touchscreen interface which, while not awful, is less easy to use than the previous generation. Most noticeably, a couple of things that previously required one tap now take two or three.

Simon Handby is just as grumpy in real life as he appears in this picture

Now a grumpy old man, I started musing on longer-term irritations. I'm still irked by software that peppers your desktop with shortcuts. I'm piqued by paper orientation icons that get covered up by paper. I'm galled by scanners that are fussy about how you orientate the originals. And I'm apoplectic every time I'm asked a yes/no question and have to respond via an OK/Cancel dialogue.

It's odd, isn't it, that firms with vast resources still foist these clunky experiences on their users? That touchscreen isn't alone: Epson annoys with its chatty Smart Panel app, while Lexmark and Xerox provide trays that are too small for European paper. Meanwhile, everyone has long tended towards pointless beeping, needless dialog boxes and requests to harvest our data – don't manufacturers even use their own products?

"Everyone has long tended towards pointless beeping, needless dialog boxes and requests to harvest our data"

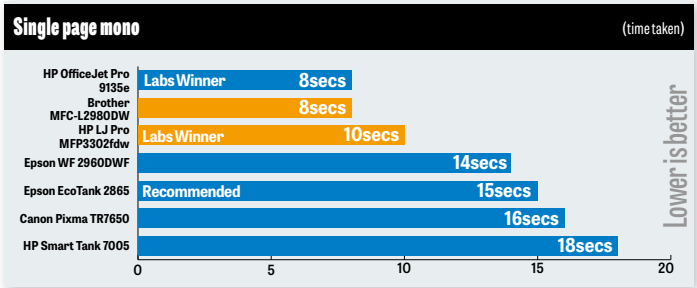
If it sounds like I hate printers, I don't. But I can't say that I love manufacturers who complicate the user experience, or want control over what you do with ink cartridges. Printers are the butt of so many IT jokes, and many of them play on these kinds of frustrations.

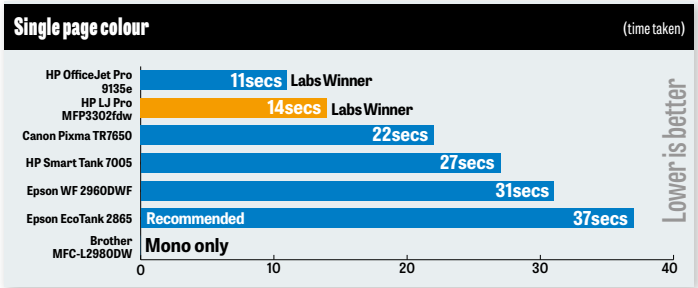
ABOVE HP's new touchscreen interface is a backwards step – unlike its new scanner platen

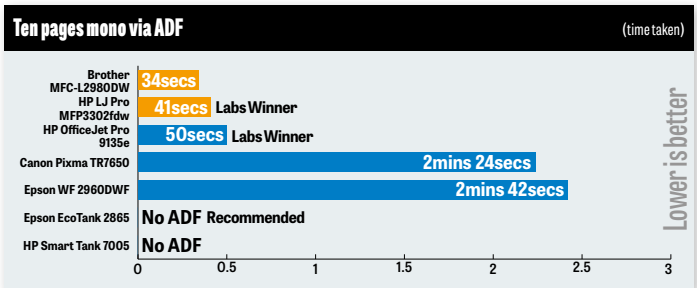
So a moment, if you will, for something as simple as HP's lipless scanner platens, which have appeared over the past couple of years. These are nothing more complex than a conventional scanner where the surrounding plastic lies flush on two sides of the glass: scan an original, then slide it off without scrabbling around for an edge. It's the smallest, simplest innovation I could imagine, yet it gives me hope that somewhere out there are engineers who actually use their products, and product managers who recognise a good idea.

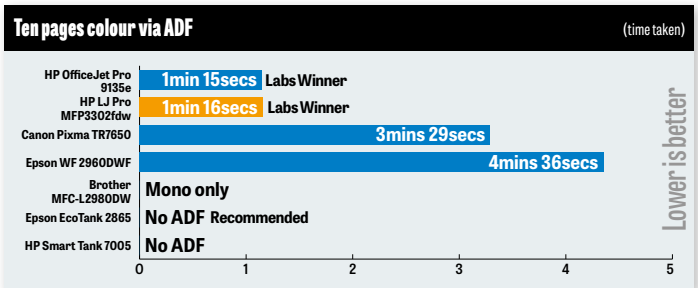
Find those people, put them in charge, and you might still find me here in another 20 years. ●

Copying tests









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Buyer's guide

Upgrade to Wi Fi 7™

Dave Mitchell reviews four business-class Wi-Fi 7 access points and explains what to look for when investing in this cutting-edge technology for business use

With over 20 billion Wi-Fi devices in use globally, businesses must adopt a wireless-first approach to network design if they want to be more flexible and competitive. Most users probably can't remember the last time they connected a device to an Ethernet cable, and now that smartphones, laptops and tablets have become their preferred mode of working, they expect wireless connectivity to be always available.

Building wireless networks is much cheaper than installing wired ones, and the seventh generation Wi-Fi 7 technology is about to make them much faster. Businesses with legacy wireless networks should be considering upgrading, and with the Wi-Fi Alliance estimating that around 233 million Wi-Fi 7 devices have already entered the market, there's no time like the present.

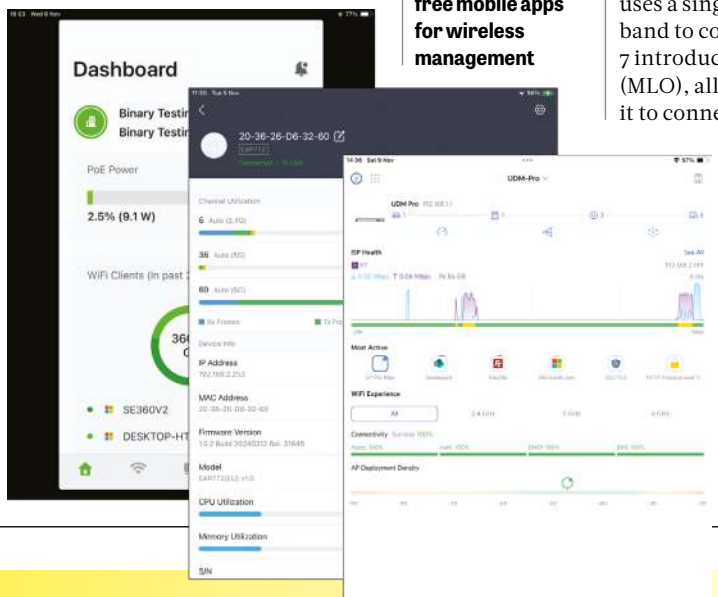
This month, we review four business-class Wi-Fi 7 access points (APs) from EnGenius, TP-Link, Ubiquiti and Zyxel. With some costing less than £140, they're all affordable options for SMBs and we've tested them in the lab to help you make the right buying decision.

What is Wi-Fi 7?

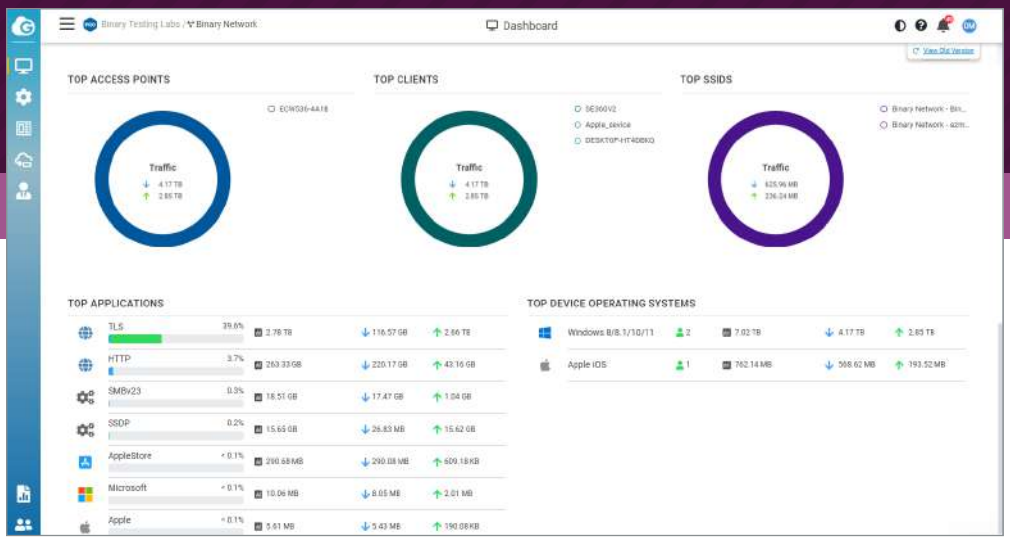
Wi-Fi 7, or IEEE 802.11be EHT (extremely high throughput), offers huge improvements in speed up to a theoretical 46Gbits/sec as opposed to 9.6Gbits/sec for Wi-Fi 6E. It supports the same 2.4GHz, 5GHz and 6GHz bands as 6E to ensure compatibility with a wide range of devices, but increases the bandwidth of the 6GHz channel from 160MHz to 320MHz and the maximum number of MU-MIMO spatial streams from eight to 16.

Transfer rates get a big boost, too, as Wi-Fi 7 takes the 1024-QAM (quadrature amplitude modulation) from Wi-Fi 6/6E and quadruples it to 4096-QAM, also known as 4K-QAM. Furthermore, whereas Wi-Fi 6/6E uses a single dynamically selected band to connect users to an AP, Wi-Fi 7 introduces multi-link operations (MLO), allowing devices that support it to connect over an aggregated link using all three bands for greater performance, reduced latency and improved reliability.

Wi-Fi 7 manages RF interference in crowded areas more efficiently with a feature called preamble puncturing, or punctured transmission. This was available in Wi-Fi 6 as an optional feature, but Wi-Fi 7 makes it mandatory.



BELOW All good vendors provide free mobile apps for wireless management



ABOVE EnGenius' smart cloud portal provides lots of information about detected apps

LEFT Ubiquiti's U7 Pro Max has a dedicated radio for real-time analysis

A problem with legacy devices and "narrow band interferers" is their ability to puncture a channel with a relatively small signal and render a large portion of it unusable or, in some cases, knock out the entire channel. Wi-Fi 7 allows APs and clients to dynamically reserve part of a channel to counter interference and maximise the potential of the 320MHz channels.

What do I need for Wi-Fi 7?

Falling Wi-Fi 7 AP prices mean they are now well within the means of SMBs, but they're not all the same so you'll need to consider the differences before diving in. Cheaper Wi-Fi 7 APs come with a 2.5GbE multi-gigabit network port, so you must ensure your network infrastructure can handle the extra demand.

You'll have to think even bigger if you want premium high-performance Wi-Fi 7 APs, as these have 10-gigabit (10GbE) ports. Power comes into the equation, too, as all business-class APs support Power over Ethernet (PoE) and most vendors expect you to use it as they don't include mains adapters; some Wi-Fi 7 APs don't even have an external power socket.

You can purchase PoE injectors if you're only using a few APs, but larger installations should invest in a PoE switch that can power them all from a single wall socket. Bear in mind that power requirements vary across Wi-Fi 7 APs as well.

Lower-performing models can get by with 802.3at PoE+ services, but larger ones need an 802.3bt PoE++ power source. We have all the bases covered for our lab testing as we use a Zyxel XS1930-12HP switch that offers eight 10GbE multi-gigabit ports all presenting PoE++ services and costs less than £900.

Cloud connected

Providing the best wireless services and coverage requires multiple APs to be deployed to avoid any dead spots.

Most APs can be managed in standalone mode using their built-in web console, but for large installations it makes more sense to choose a vendor that offers cloud management.

All the APs in this guide can be cloud-managed regardless of where they're physically located, making them ideal for businesses with geographically distributed offices and home workers. From a single web portal, you create sites for each location, add secure wireless networks, decide which APs will broadcast them and keep a close eye on network health, client connections and bandwidth usage.

The two most common methods of cloud management are quite different so it's worth delving deeper to ensure you pick the right one for your circumstances. One requires a controller appliance that manages all APs and wireless networks within the site on which it's physically located.

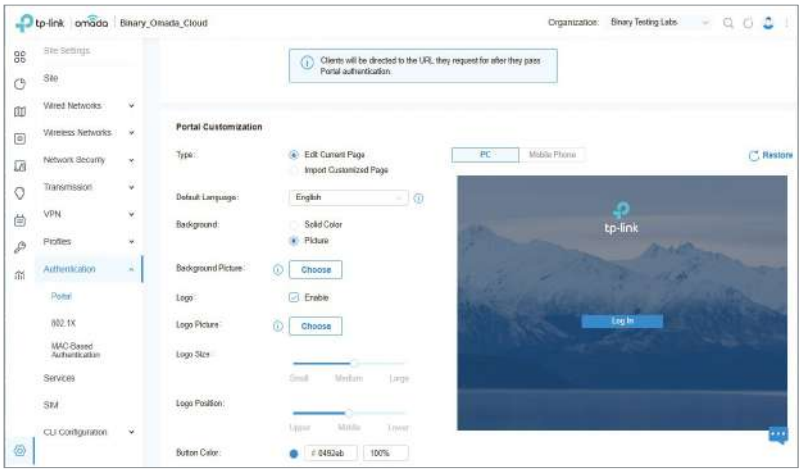
All good vendors provide free software controllers that require a host PC, but you can avoid this as most offer affordable pre-configured hardware appliances with some now providing cloud-hosted controllers. These are registered with your cloud portal account, and selecting one takes you to the site it's managing.

> "All business-class APs support PoE and most vendors expect you to use it as they don't include mains adapters"

A simpler alternative is a direct connection where APs are registered with your cloud account and then appear in its portal. You create virtual sites within the cloud portal to represent your offices, and APs only broadcast the SSIDs in the site they are members of.

Both methods have their pros and cons, with on-site appliances a good choice for large wireless networks as they keep most management traffic on-site. Direct cloud connections are better for providing secure wireless networks to smaller businesses and home workers as you won't need to install an on-premises controller.

As demand has increased, prices for Wi-Fi 7 APs have dropped substantially over the past few months, making them very cost-effective for SMBs. The increased performance, higher capacity and reduced latency will satisfy even the most demanding of users and customers, so turn the page to see which of the four solutions on review best fits your wireless upgrade plans.



LEFT TP-Link offers wireless captive portal design tools in its cloud portal

EnGenius ECW536

A cloud-managed business Wi-Fi 7 access point that's competitively priced and seriously fast

SCORE ★★★★★

PRICE £386 exc VAT from solwise.co.uk

EnGenius has traditionally offered businesses a fine choice of wireless access points, and its flagship ECW536 is easily the most powerful. This large, BE19000-rated AP presents a total of 12 spatial streams – four each for its 2.4GHz, 5GHz and 6GHz bands, with theoretical maximum speeds of 1,376Mbits/sec, 5,764Mbits/sec and 11,529Mbits/sec respectively.

The ECW536 supports the Wi-Fi 7 6GHz HE 320MHz channels and has the hardware to handle high demand. Powered by Qualcomm's Networking Pro 1220 platform featuring a quad-core Arm Cortex-A73 CPU, it offers two 10GbE ports. The main one requires an 802.3bt PoE++ power source and the second is provided for networking other devices.

All ECW AP models are designed to be directly managed from the EnGenius cloud portal. Their local web browser interfaces don't provide access to any configuration settings and only display details of LAN, internet and cloud connection status.

Adding the ECW536 to our cloud account was easy as we used the Cloud To-Go iOS app on an iPad to scan the QR code on its base. The AP was automatically added to our organisation, where it took all our predefined wireless settings and started broadcasting them as soon as it was online.

The cloud portal sees a few minor design changes but, if you prefer the older version, you can swap over to it with one click. In either case, the non-customisable dashboard provides plenty of information on all switches, APs and wireless clients, with graphs below for wireless throughput as well as the top APs, clients and SSIDs.

Up to eight site SSIDs are supported. For each one, you can choose the active radios, enable L2 isolation, band steering and fast roaming, and apply download and upload rate limits for the entire SSID or per client. EnGenius won't allow open, unsecured SSIDs to be created so you must choose from opportunistic wireless encryption (OWE) to present safe open public networks or the appropriate WPA version, and there's also an option to enable multi-link operations (MLO) for its Wi-Fi 7 APs.

EnGenius offers a chargeable Pro version of the cloud portal, which enables a range of enhanced features such as a 30-day log-retention period, network topology views and seven-day timeline charts of the APs to which a client connected, the authentication methods used and details of association errors such as incorrect passwords. The ECW536 includes a one-year Pro subscription in the price, with subsequent years costing around £38 per device.

Captive portal features are outstanding, as you can present wireless guests with custom splash pages created using the portal's integrated HTML editing toolbox. Standard authentication methods include local user accounts, Radius and vouchers with a Pro licence enabling LDAP, Active Directory, Google LDAP and Azure AD.

The ECW536 more than delivers on its performance promises. For testing, we hooked it up to the lab's Zyxel XS1930-12HP 10GbE PoE++ switch and used a Lenovo Windows 11 Pro 24H2 desktop client equipped with a TP-Link Archer TBE550S Wi-Fi 7 PCI-E adapter. Using Microsoft's NTttcp utility, we recorded impressive raw upstream and downstream rates of 418MB/sec and 380MB/sec respectively between the client and a Windows server on our 10GbE LAN.

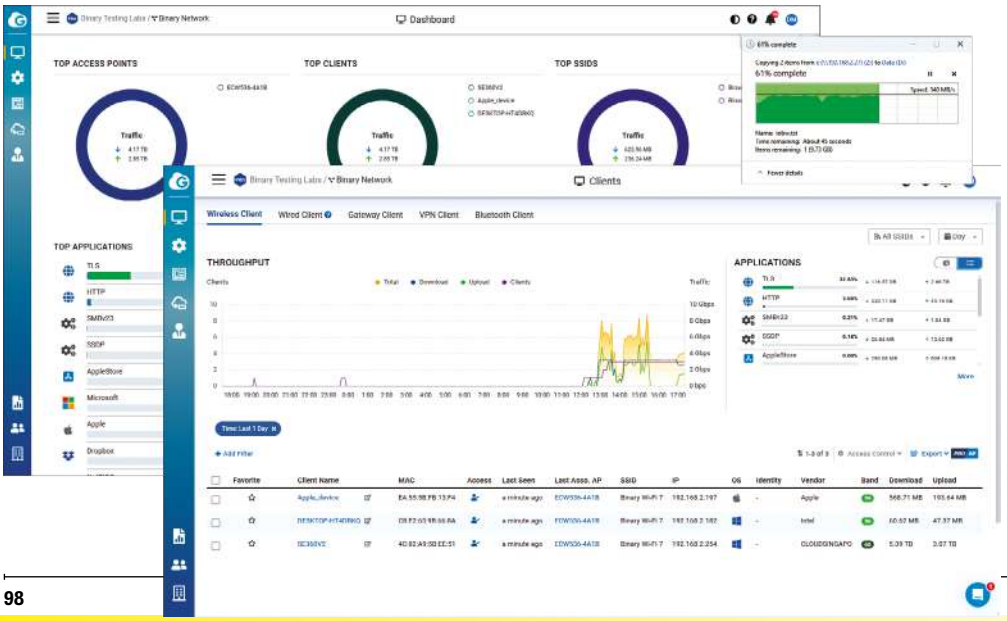
Real-world speeds are good, too, with close-range large file copies between the client and server averaging a speedy 335MB/sec. With the AP moved ten metres away and into an adjoining room, we recorded top average copy speeds of 295MB/sec.

The ECW536 delivers on all fronts; this mighty BE19000-rated Wi-Fi 7 AP is impressively fast and incredibly good value. It can only be cloud-managed, but the EnGenius portal is easy to use and delivers a wealth of wireless management and monitoring services.

ABOVE EnGenius' ECW536 is great value for such a powerful AP

PC PRO RECOMMENDED

"The ECW536 supports the Wi-Fi 7 6GHz HE 320MHz channels and has the hardware to handle high demand"



BELOW The cloud portal offers plenty of management features

SPECIFICATIONS

BE19000 tri-band 2.4GHz/5GHz/6GHz 802.11be • quad-core Arm Cortex-A73 CPU • 12 x internal aerials • 10GbE LAN/802.3bt PoE++ • 10GbE LAN • wall/ceiling mount kit • 12V DC input (adapter not included) • 230 x 230 x 37mm (WDH) • 1.3kg • 1yr Cloud Pro licence included • 2yr hardware warranty

TP-Link Omada EAP772

Modest performance, but this slimline Wi-Fi 7 AP offers lots of features and great remote management at a low price

SCORE ★★★★☆

PRICE £133 exc VAT from broadbandbuyer.com

TP-Link was one of the first networking vendors to deliver a business Wi-Fi 7 AP, with its mighty EAP783 (*see issue 360, p103*) setting a high standard for wireless performance. SMBs less impressed with its £520 price tag may find the firm's EAP772 a more appealing alternative as it costs only £133.

Naturally, there are compromises, with the 10GbE port in its bigger brother being replaced by a 2.5GbE multi-gigabit port. It has a much lower BE9300 rating, which claims to deliver up to 573Mbits/sec on its 2.4GHz radio, 2,880Mbits/sec on 5GHz and 5,760Mbits/sec on 6GHz with the ultrawide Wi-Fi 7 320MHz channels enabled.

That's still a good deal considering the price, and the EAP772 also supports the Wi-Fi 7 MLO feature. This allows compliant end-user devices to simultaneously connect to multiple bands on the AP for increased throughput and reduced latency.

The AP's 2.5GbE port requires an 802.3at PoE+ power source, and there's a socket next to it for TP-Link's optional 12V adapter. This 220mm wide discus is designed to be ceiling-friendly: it's only 32.5mm thick and weighs 716g – half that of the EAP783.

In standalone mode the AP's web console wizard requests a new username and password and then deletes the default admin account for added security. Eight SSIDs per radio are supported, and the wizard asks you to configure the first three and provide new encryption keys.

For performance testing, we connected the AP to the lab's Zyxel XS1930-12HP 10GbE PoE++ switch and used a Lenovo desktop client running Windows 11 Pro 24H2 and fitted with a TP-Link Archer TBE550S Wi-Fi 7 PCI-E adapter. To gauge raw performance, we used the NTttcp utility, which reported upstream and downstream speeds of 219MB/sec and 201MB/sec respectively.

Real-world performance was noticeably lower, with large file copies between the client and a Windows server on our 10GbE LAN averaging top close-range speeds of 192MB/sec. Moving the AP ten metres away and into an adjoining room saw copy speeds drop to 181MB/sec.

Remote management options are impressive. You can install TP-Link's hardware and free software controllers on-site or use its cloud-based controller, which has a yearly fee of £165 for 250 devices. The main Omada portal simplifies multi-site management as it presents a list of all controllers assigned to your account.

ABOVE The EAP772 is an affordable entry point into the Wi-Fi 7 world

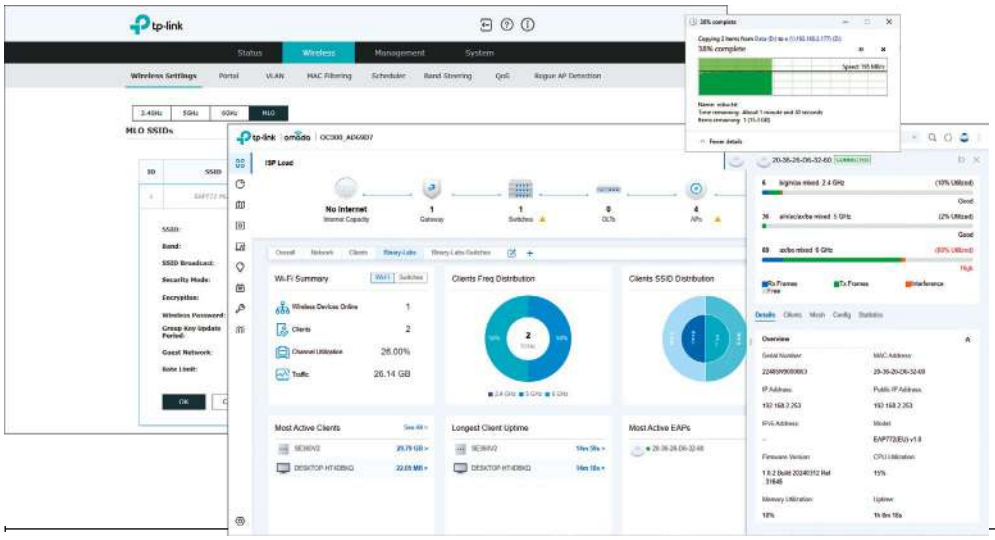
We use TP-Link's OC300 appliance, and selecting it took us to its own portal, which presented a customisable dashboard and a ribbon across the top showing internet capacity, gateway usage, switches, APs, clients and guests. Adding the EAP772 was simple as it automatically appeared as "pending" and, once adopted, took all its settings from the controller and broadcast our predefined SSIDs.

The cloud portal supports the same number of SSIDs as standalone mode. From the site settings page, you can easily create new ones and apply encryption schemes, rate limits and MAC address filters. MLO-enabled SSIDs can be configured with a few clicks, and schedules can be used to determine when SSIDs are active.

> **"Cloud management enables a number of additional features. Wireless coverage can be extended using meshing"**

Cloud management enables a number of additional features. Wireless coverage can be extended using meshing, and any SSID can be set as a guest network where L2 isolation is automatically applied so clients only receive internet access. Captive portals can be assigned to SSIDs by creating profiles using a range of authentication methods and options to present custom portal pages with your own choice of colours, logos and messages.

TP-Link's EAP772 offers SMBs an affordable entry point into the world of Wi-Fi 7. Performance is reasonable and it delivers plenty of business-class features for the price, while TP-Link's Omada cloud portal makes light work of remote management.



BELOW The EAP772 can be used in standalone mode or cloud-managed

SPECIFICATIONS

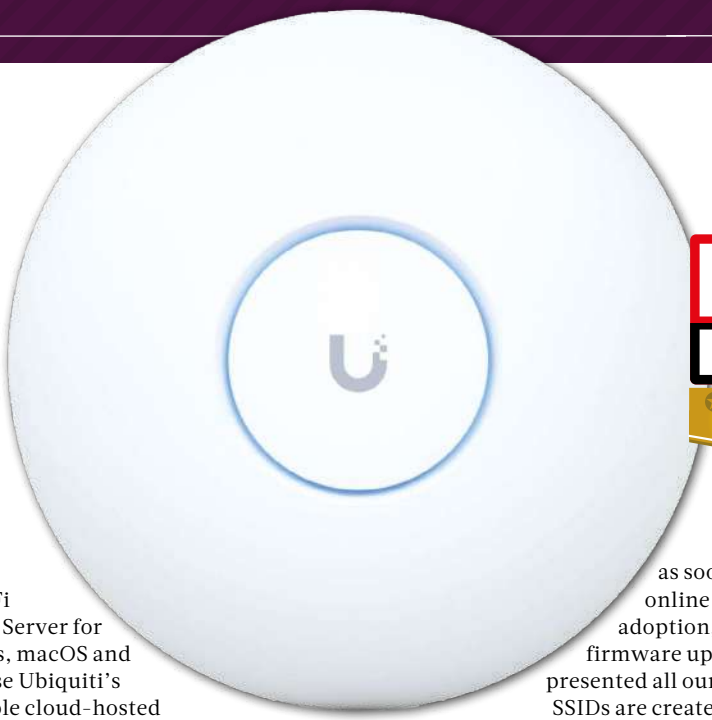
BE9300 tri-band 2.4GHz/5GHz/6GHz 802.11be • 6 x internal aerials • 2.5GbE LAN/802.3at PoE+ • ceiling/wall mount kits • 220 x 220 x 33mm (WDH) • 716g • DC power adapter not included • standalone or Omada cloud management • limited lifetime warranty

Ubiquiti UniFi U7 Pro Max

A great-value business Wi-Fi 7 AP with good performance and outstanding wireless management services

SCORE ✪✪✪✪✪

PRICE £214 exc VAT
from broadbandbuyer.com



PC PRO ✪✪✪✪ A-LIST

The UniFi family from Ubiquiti has always impressed us with its classy wireless network management solutions, and the company makes its play for the business Wi-Fi 7 space with four access points. Along with outdoor and wall-mounted models, there's the entry-level U7 Pro, while for this review we tested the flagship UniFi U7 Pro Max.

This sleekly designed BE15000-rated AP offers a lot for its modest price. Along with eight spatial streams for improved coverage, it has a dedicated radio for real-time spectral analysis so it can run non-disruptive scans. As with most competing Wi-Fi 7 APs at this price, you get a 2.5GbE multi-gigabit port supporting an 802.3at PoE+ power source, which you'll need as the AP doesn't have a socket for an optional external power adapter.

Everything about the U7 Pro Max oozes class, ranging from the great build quality to the metal plates and complete toolkit in the box. This has all the components for wall-mounting and all types of ceiling; the mounting template card even has a built-in spirit level.

Management options are incredibly diverse. You can install the free UniFi Network Server for Windows, macOS and Linux, use Ubiquiti's chargeable cloud-hosted controller or choose from a range of UniFi Cloud Gateways. For testing, we used the lab's UniFi Dream Machine Pro (UDM Pro) appliance, which costs around £310 and teams up wireless network management with gateway security as well as video surveillance, motion detection and recording services.

We could view all remote gateways from our Ubiquiti Site Manager cloud portal, and selecting the UDM Pro transported us to its own management console. This is a joy to behold and provides everything you need to know about your networks, with detailed topology views, lists of all managed UniFi devices and deep insights into connected clients, with a complete traffic breakdown along with icons showing the top detected apps and their individual bandwidth usage.

For testing, we used a Zyxel XS1930-12HP 10GbE PoE++ switch, which the UDM Pro recognised and added to its topology view as a new client. Deploying the U7 Pro Max was equally easy: it appeared in the console as soon as it came online and after adoption, it received a firmware upgrade and then presented all our predefined SSIDs.

ABOVE The UniFi U7 Pro Max is the best Wi-Fi 7 AP you can buy

SSIDs are created from the console's settings page, where you assign radios and choose from a range of options, including the preferred encryption scheme, client isolation, rate limits and captive portals, and enabling the enhanced IoT feature limits the network to the 2.4GHz band if you're having device connectivity issues. From the Radio Manager page, we enabled the Wi-Fi 7 320MHz channels but noted that the MLO feature is yet to be supported.

> **"The management console is a joy to behold and provides everything you need to know about your networks"**

We ran our tests using a Lenovo Windows 11 Pro 24H2 desktop client equipped with a TP-Link Archer TBE550S Wi-Fi 7 PCI-E adapter and a Windows Server 2022 host on the 10GbE LAN. Raw performance is very good, with Microsoft's NTttcp utility reporting upstream speeds of 264MB/sec and 215MB/sec downstream.

Real-world performance is not to be sniffed at either, with close-range large files copies between the client and server returning top average speeds of 200MB/sec. With the AP placed ten metres away and in the next room, we recorded respectable speeds of 183MB/sec.

Ubiquiti's UniFi U7 Pro Max is a great choice for SMBs seeking a powerful and affordable upgrade to Wi-Fi 7. You'll need a UniFi controller to complete the wireless picture, but this modest investment will be paid back handsomely as they offer the best cloud management services on the planet.

BELOW The U7 Pro Max comes with clever real-time spectral analysis

SPECIFICATIONS

BE15000 tri-band 2.4/5/6GHz 802.11be • eight internal aerials • 2.5GbE multi-gig LAN/802.3at PoE+ • ceiling/wall mounting kit • 206 x 206 x 46mm (WDH) • 680g • 2yr standard warranty

Zyxel NWA130BE

This affordable Wi-Fi 7 AP delivers a good feature set and cloud management but below-par performance

SCORE ★★★★☆

PRICE £133 exc VAT from broadbandbuyer.com

Small businesses nervous about the cost of delivering Wi-Fi 7 services can breathe easy with Zyxel's NWA130BE, a tri-band access point that delivers an impressive range of features at a very tempting price. Its BE11000 rating makes big performance promises and it supports standalone mode or cloud management from Zyxel's slick Nebula Control Center (NCC) portal.

The NWA130BE presents six spatial streams, with two each for 2.4GHz, 5GHz and 6GHz radios. Its main 2.5GbE multi-gigabit port requires an 802.3at PoE+ power source, or you can use an optional 12V DC adapter, plus there's an extra 2.5GbE LAN port for networking other wired devices.

The lozenge-shaped casing is sturdily constructed, and the box includes a universal bracket for mounting on the wall or ceiling. Drop ceilings are supported, with Zyxel offering an optional set of clips at around £22 for a five-pack.

Before we delve any deeper, it's worth mentioning that Zyxel's more expensive WBE530 model is physically identical to the NWA130BE. However, the WBE530 is a NebulaFlex Pro version that comes with a one-year NCC Pro Pack licence, includes Zyxel's collaborative detection and response (CDR) security service and supports management from Zyxel's NXC on-premises controllers or ATP/USG security appliances.

Installation of the NWA130BE in standalone mode is ably assisted by a web console wizard that guides you through setting the country of operation, changing the default admin password and creating radio profiles for the three bands. The AP supports up to eight SSIDs, and you can use custom profiles and objects to assign selected radios and enable features such as upload and download rate limits and QoS for prioritising voice or video traffic.

With the AP hooked up to the lab's Zyxel XS1930-12HP 10GbE PoE++ switch, we ran performance tests using a Lenovo Windows 11 Pro 24H2 desktop client equipped with a TP-Link Archer TBE550S Wi-Fi 7 PCI-E adapter.

Starting with Microsoft's NTttcp utility, we recorded raw upstream and downstream speeds of 213MB/sec and 202MB/sec respectively. Our real-world large file copies between the client and a Windows server on the 10GbE LAN averaged close-range speeds of 183MB/sec, dropping to 171MB/sec with the AP moved ten metres away.

ABOVE The NWA130BE is a sturdy AP that's also terrific value

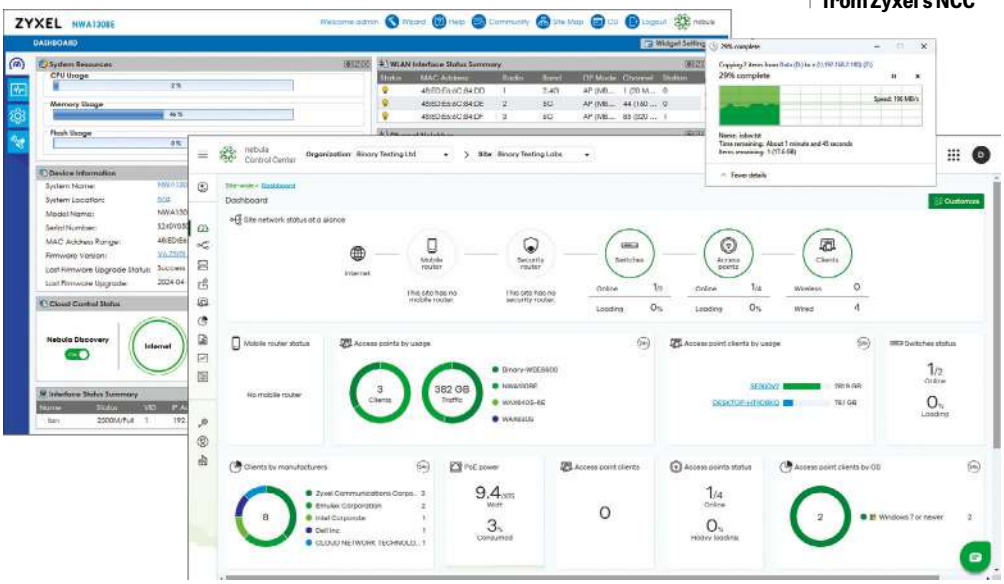
If you want features such as Wi-Fi 7 MLO and captive portals for guest access you'll need to move to cloud management, but this is easy to do. We logged into our cloud account using the NCC app on an iPad, selected our site and scanned in the QR code on the AP's label. The app instantly picked up its MAC address and model name, added it to the site and, five minutes later, the AP started broadcasting our cloud-managed SSIDs.

> **"The NCC portal presents an informative dashboard with customisable widgets showing the status of all Zyxel cloud-managed devices"**

The NCC portal presents an informative dashboard with customisable widgets showing the status of all Zyxel cloud-managed devices, total wireless traffic, APs by usage, all connected wireless clients along with their detected OS, and PoE consumption for our Zyxel switch. Up to eight site SSIDs are supported where you choose your encryption scheme and use tags so they're only broadcast by APs that match it.

MLO can be enabled on selected SSIDs, but bear in mind it will disable many features including smart meshing, rate limits, traffic shaping and L2 isolation. Captive portals are of more use as you can create multiple designs using custom logos and messages, with the SSID's advanced settings offering a good range of authentication methods.

Wireless performance isn't great but the NWA130BE will appeal to SMBs that want a budget-friendly Wi-Fi 7 upgrade. It's well built and easy to deploy with Zyxel's NCC offering smart cloud management.



BELOW It can be managed in standalone mode or from Zyxel's NCC

SPECIFICATIONS

BE11000 tri-band 2.4/5/6GHz 802.11be • six internal aerials • 2.5GbE multi-Gig LAN/802.3at PoE+ • 2.5GbE LAN • 12V DC power input (adapter not included) • ceiling/wall mounting plate • 250 x 160 x 47mm (WDH) • 808g • limited lifetime warranty

Barco ClickShare Bar Pro

A tad pricey, but this smart all-in-one VC bar delivers good quality and offers fast meeting creation abilities

SCORE ★★★★☆

PRICE £2,716 exc VAT
from ballicom.co.uk

Barco's ClickShare Bar Pro is an all-in-one videoconferencing (VC) solution, but not as we know it. The clue is in the name: it uses Barco's clever ClickShare Button technology to wirelessly create instant meetings.

It sports a 4K camera with a big 120° field of view (FoV) and employs digital pan, tilt and zoom (PTZ) operations. Speaker tracking is handled by a six MEMS microphone beamforming array, while audio output is delivered by a pair of 10W ported speakers.

Behind the rear cable-tidy panel you'll find an HDMI port for display connection, along with two USB-C 3.2 Gen 1 ports, one of which can be used to power a compatible monitor, with the second supporting DP Alt mode for connecting a client device using an active USB cable. Network features include a gigabit port and a Wi-Fi 5 access point, and the bar presents a web browser console and can be remotely managed from Barco's XMS cloud portal.

This is where any similarity with standard VC bars ends. Client devices access the ClickShare Bar Pro with the ClickShare Buttons or Barco's desktop and mobile apps. Barco's CX range of ClickShare wireless conference products comprise a base unit to which you connect a third-party VC solution such as Logitech's MeetUp and Rally products.

The ClickShare Bar Pro is essentially a base unit with integrated camera and audio. It comes with two Buttons in the box, with the cheaper Core model including one Button and lacking support for speaker framing and dual displays.

Installation is simple, with the bar's web interface providing easy access to all features. You can set a custom wallpaper to appear on the monitor when it's idle, choose from the four speaker tracking modes and apply one of three preset security levels to protect against unauthorised access.

After adding the review unit to our free Barco XMS cloud account, it appeared as a new base unit. The portal is one of the best we've seen for VC device management as it reveals a wealth of graphical statistics and charts on meetings, conferences plus presentations and provides full remote configuration access to base units.

We started testing with Barco's Windows desktop app, which discovered the bar on the network. After we entered the unique four-digit code displayed on the bar's monitor, it created a connection and presented the client with three new Windows devices: a Barco room monitor, microphone and speakers. At this stage, you can run any VC meeting app you want, and the app also allows you to present your screen contents on the room monitor.

Video quality is good, with the camera delivering a sharp image, good colour balance and efficient backlight compensation. The bar was quick to respond to movement, snapping to the active speaker in under three seconds, and remote participants said they could hear us clearly. Although we expected a bit more punch from the dual 10W speakers, an 80% volume level was enough to fill our 24m² meeting room.

Before use, the Buttons must be paired with the bar by plugging each one into the USB-C port on the side. It's completely automated, with the local monitor providing a progress bar on the pairing process.

Users then just plug the Button into their personal device and watch it instantly pair with the bar over a private, encrypted Wi-Fi connection. A light version of the client is stored on the Button, but for the full experience they can install the main desktop client and use the virtual remote app to choose a tracking mode and manually control PTZ functions.

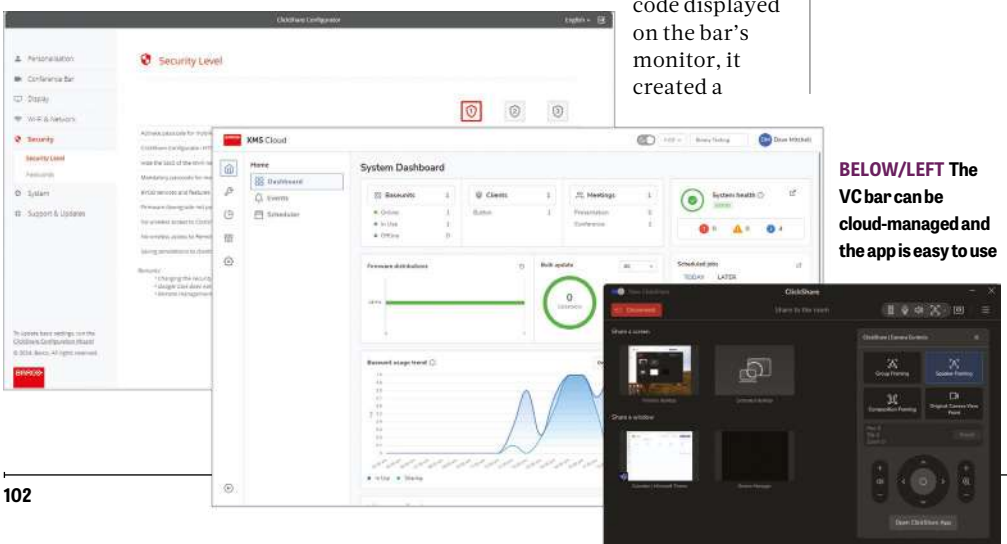
The ClickShare Bar Pro is a comparatively expensive all-in-one VC bar, but points lost for value are recouped for sheer ease of use. The innovative use of Buttons makes meeting setup a breeze, and Barco's smart XMS cloud portal is ideal for managing all your ClickShare real estate. **DAVE MITCHELL**

ABOVE The ClickShare Bar Pro is incredibly easy to set up and use

PC PRO RECOMMENDED

LEFT The 4K camera has a wide 120° field of view

> **"The bar was quick to respond to movement, snapping to the active speaker in under three seconds"**



BELOW/LEFT The VC bar can be cloud-managed and the app is easy to use

SPECIFICATIONS

4K UHD camera • 120° FoV • digital PTZ (3x zoom) • 6 x MEMS mic array • 2 x 10W speakers • gigabit Ethernet • Wi-Fi 5 • HDMI out • 2 x USB-C 3.2 Gen 1 • DP in/out; USB-C 2 (pairing) • USB-A 2 • 2 x Gen4 ClickShare Buttons • table/wall mount • external PSU • 640 x 101 x 93mm (WDH) • 2.5kg • 5yr warranty with SmartCare registration

Epson WorkForce DS-800WN

Wins for its speed, high-quality output and integration with Epson's great document management platform

SCORE ★★★★★

PRICE £656 exc VAT
from ballicom.co.uk

ABOVE Epson's DS-800WN is a quick scanner that's also highly customisable

The WorkForce DS-800WN aims to be one of Epson's most versatile A4 desktop scanners yet. A member of Epson's ScanWay club, it can function as a standalone network device for walk-up scanning, while support for Epson's Open Platform (EOP) means it can be easily integrated into Epson's scanner management tools and products developed by third-party independent software vendors (ISVs).

EOP allows ISVs to customise the scanner so it fits in seamlessly with their software solution. Epson works with a range of ISVs, including DocuSoft, which can embed its document and data management software in the scanner's web GUI and customise the icons on the touchscreen.

DocuSoft tightens security as all users must authenticate at the scanner to use it, with all scans automatically catalogued, indexed and placed in the desired storage repository. EOP support also allows the DS-800WN to work happily with Epson's Device Admin for centralised fleet management as well as its Print Admin (EPA) and EPA Serverless for user authentication and secure scanning services.

As a straightforward sheet-fed desktop scanner, the DS-800WN teams up a nippy 50ppm scan speed with a capacious 100-sheet automatic document feeder (ADF) and a solid 8,000-page daily duty cycle. Connection options abound: along with a USB-A 3.2 Gen 1 port, it has an integral gigabit LAN port and Wi-Fi 5 services.

The generous 10.9cm colour touchscreen is ideal for walk-up scanning, with icons for sending documents directly to computers, network folders, FTP servers, email, a local USB stick, cloud storage providers and Windows PCs using WSD (web services for devices). Computers are displayed in the touchscreen once they have Epson's software installed, while other network destinations are enabled from the scanner's web console.

We used the web console to register the scanner with our Epson's Connect portal account and could then create scan-to-cloud destinations that appeared in the touchscreen for quick selection. There's a big choice, with Connect supporting email, SharePoint, Teams, Box, Dropbox, OneDrive, Google Drive and EverNote.

PC PRO RECOMMENDED

"The DS-800WN teams up a good 50ppm scan speed with a capacious 100-sheet ADF and a solid 8,000-page daily duty cycle"

Deploying the drivers and software on our Windows 11 PCs was simple: we visited Epson's support site, entered the model name and ran the downloaded utility. This deftly handled device discovery, driver downloads, installation of Epson's Scan 2 and Document Capture Pro utilities and a firmware update.

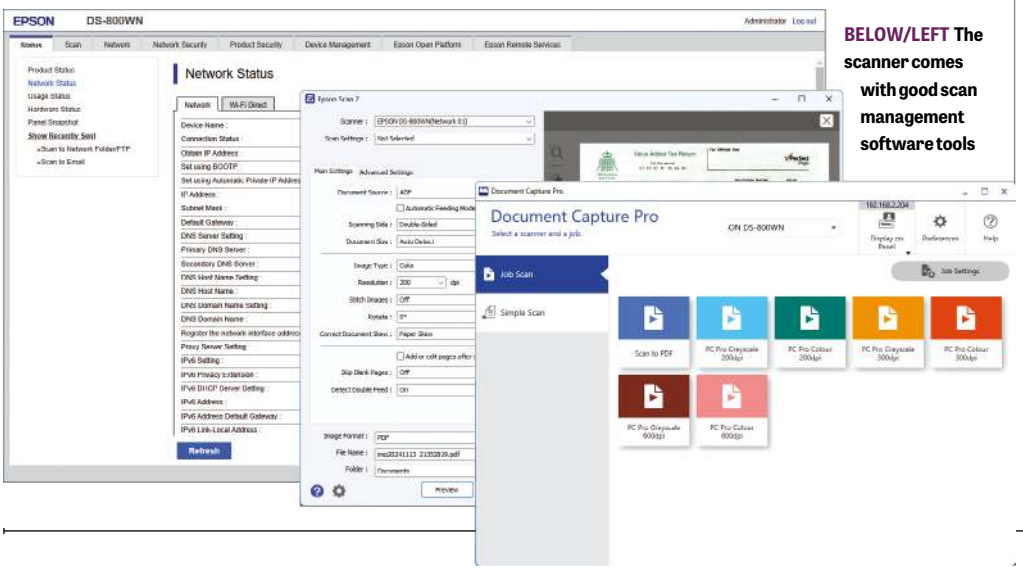
The Scan 2 utility provides plenty of scan controls and is loaded when acquiring scans from third-party products using the TWAIN driver. You can select a resolution, colour, greyscale or mono scans, document and contents skew correction, simplex or duplex operations and blank page skipping.

Document Capture Pro provides excellent scan management tools. You can create a range of jobs that comprise scan settings, output formats and destinations, job separation using barcodes, patch codes or OCR detection areas and save them for one-click access. Each PC appears in the scanner's touchscreen so scans can be sent directly to them, and assigning button numbers to selected jobs on each PC makes them available for selection as well.

Performance is on the money, with our stack of 50 well-thumbed bank statements scanned at the quoted 50ppm for greyscale and colour at both 200dpi and 300dpi resolutions. Increasing the resolution to 600dpi also returned respectable speeds of 19.2ppm.

A high resolution won't be needed for document archiving, though, as greyscale output quality at 200dpi is perfectly acceptable for these tasks, with the Document Capture Pro OCR service correctly converting every word on our statements down to 6pt fonts. The scanner was very quiet when scanning our test documents and paper handling was perfect as we didn't suffer a single paper jam.

Epson's WorkForce DS-800WN is a flexible desktop scanner with a good turn of speed and lots of connection options. Epson's software provides great scan management features, and support for EOP makes it a fine choice for businesses that want to integrate it into their document management processes. **DAVE MITCHELL**



BELOW/LEFT The scanner comes with good scan management software tools

SPECIFICATIONS

600dpi A4 colour scanner • 50ppm @ 300dpi colour/mono • simplex/duplex • 100-page ADF • 10.9cm colour touchscreen • USB-A 3.2 Gen 1 • gigabit Ethernet • Wi-Fi 5 • rec. daily duty cycle, 8,000 pages • external PSU • Epson Scan 2, Document Capture Pro software • 296 x 169 x 167mm (WDH, closed) • 3.6kg • 1yr on-site service warranty

Get ready for the biggest security threats of 2025

Forewarned is forearmed: Davey Winder explores the likely online risks of the year ahead

As a new year dawns, IT managers will naturally be wondering what threats 2025 will bring. And I hope you're sitting down, because here comes my shocking prediction: the major risks will be… broadly the same as they were in 2024. While we can never be complacent about security, completely new modes of attack emerge quite rarely, and certainly not to an annual schedule.

But that doesn't mean you can relax. While the nature of the threats may be broadly the same from one year to the next, the methods are always evolving, becoming smarter and more subtle. And that means your security defences need to evolve along with them.

And it's not just the biggest organisations that need to keep up. As we've said so many times in the past, SMBs are far from immune to cybercrime: if you have a bank balance and customer data, you're fair game to a hacker.

In fact, with larger organisations making major investments in cybersecurity, smaller businesses are becoming more attractive targets, as they tend to be less well protected than enterprises.

So what are the emerging threats, and how can you protect yourself from them? Let's start with the most common threat facing organisations today, tomorrow and throughout 2025 – phishing.

The evolution of phishing attacks

There are plenty of names bandied about these days for different modes of social engineering attack, such as "vishing" (phishing with voice calls), "quishing" (deceptive QR codes) and so forth. But whatever you call it, tricking authorised users into compromising their credentials remains the single biggest threat to most organisations. It's an effective and cost-efficient method for attackers to gain initial access to a network, hard to defend against – there are no patches available for human nature – and especially tricky because it can take so many forms, as all those silly names bear witness to.

"Tricking authorised users into compromising their credentials remains the single biggest threat to most organisations"

In 2025 we can expect to see phishing continue to become more sophisticated. The days of wannabe cyber-gangsters spraying generic messages across millions of email addresses, in the expectation of reeling in just 1% with the bait are all but over. Phishing has become much more directed and specialised, from initial-access brokers who sell network access through fraudsters targeting specific companies or employees for a profitable payday, and ending up with groups acting on behalf of nation states. They use persistent and laser-focused targeting of individuals, often for purposes of surveillance rather than extortion or disruption.

BELOW AI deepfakes raise the stakes when it comes to online impersonation

This evolution of phishing is hugely supported by AI. For example, we're increasingly seeing attackers make use of "deepfakes" – AI-generated voice or even video messages that look and sound convincingly like, say, a company director. Just a couple of years ago, such technology was too expensive and resource-heavy for regular cybercriminals to use, and remained firmly in the nation-state basket of weapons. Today,

staggeringly good virtual imposters are easily within reach, and can be used to convince employees to hand over credentials, or even sign off financial transfers on the apparent say-so of a senior director.

This isn't a theoretical threat. Assaf Rappaport, the CEO of disruptive cloud security company Wiz, recently revealed how he had himself been cloned. Wiz employees received a voice message seemingly from him, but immediately recognised that something was off: Rappaport suffers from public-speaking anxiety, and the fake audio had been created using a recording of him talking at a conference, where his voice sounded quite different to how he would usually speak in a one-to-one conversation. That stroke of luck exposed the fakery, but others won't be so fortunate.

Here's an example illustrating another nefarious use of AI: Sam Mitrovic, a Microsoft solutions consultant specialising in security, almost fell victim to a super-realistic phishing attack in the form of a contact from "Google Support", asking him to confirm a password reset request. The attack started with a bog-standard "click here" message, but was then followed within the hour by a telephone call from an AI-generated support worker, seeming to confirm the request.

In the end, the attack failed because Mitrovic twigged that the voice was computer-generated, and asked for a confirmation email – which duly arrived, but from a bogus address that gave the game away. It's easy to see how such red flags could easily have been missed by a busy person trying to deal with what appeared to be a bona fide security request.

Before we move on, it's worth quickly mentioning a couple of other evolving phishing attack methodologies:

1 The abuse of Google Forms, the free online document creation tool that's part of Google Workspace. Using this service allows attackers to share documents that come from a genuine Google address (workspacesupport@google.com), adding the appearance of legitimacy to the fraud.

2 Automated detection-tool avoidance by adding human interaction – for example, prompting someone to "click here", but instructing the victim to hold down the Ctrl key while clicking.

Bad practice

At the risk of sounding like an old-fashioned teacher, the biggest danger to businesses in 2025 is their own bad practice. Whether it's through a lack of clear security policies, insufficient planning or relying upon the same old protections as they have for the past decade, companies are leaving themselves exposed to attack and major disruption when it happens.

A lack of planning is perhaps the most insidious risk. That doesn't just mean putting things down on paper: I've known businesses with carefully considered, painstakingly drafted incident response processes – which nobody in the organisation has any experience of using. In the high-stress scenario of an unfolding security incident, the last thing anybody needs is a bunch of people all opening up a set of instructions for the first time and trying to figure out who does what and when.

As for the same old protections, I hardly need to explain the foolishness of relying on non-AI-aware security tools in an age when the attackers are all employing AI-driven exploits. Get with the programme and at least investigate how AI could help rather than hinder your operations from the security perspective.

If all of this sounds like a complex and expensive burden, I sympathise. Depending on the size and nature of your business, it can be a major distraction to try to stay up to date with network security at the same time as running your core business. If you're in such a situation, consider outsourcing your security operations to a third party that can keep on top of them for you.

There's one last type of bad practice that I continue to see every week, and that's bad password management. I'm not solely blaming the users here, but over-enthusiastic admins, too: in 2025, nobody should be insisting employees change their passwords every few months. In theory, yes, it's a good idea to ensure that any stolen credentials will only have a short window of validity. But the National Cyber Security Centre has been advising against forced password changes for a decade because, and I quote: "The chances are that the new password will be similar to the old one."

Rather, if there's only one security change you make in the coming year, one of the best things you can do is ditch passwords altogether, and switch to digital passkeys. These provide stronger confirmation of someone's identity, while being easier to use – and far harder to steal. Stop attackers from gaining initial access and you'll be well protected against the latest evolutions and developments in the never-ending security arms race.

ABOVE Even 2FA doesn't guarantee accounts can't be compromised

Automatic analysis tools won't simulate these unusual behaviours, and so won't observe what happens next.

What can you do about such threats? The usual answers of awareness and education naturally apply, but organisations should also be employing internal access controls and monitoring to detect anything out of the ordinary – even something not obviously dangerous – as soon as it happens. Robust procedural policies are valuable, too, to defend against the likes of business email compromise, invoice fraud and other standard phishing threats.

Ransomware rises yet again

Last year saw several news stories about global law enforcement co-operation taking down big ransomware networks, and even arresting key players in high-profile cybercrime groups, so you might think you can relax a little in 2025, at least as far as that particular threat is concerned.

"A dual-threat tactic is now standard for most ransomware operators, where data is exfiltrated before the lockdown"

The truth, and it's a bitter one I admit, is that when you cut the head off one such group at least two or three smaller ones emerge and carry on. The ransomware Hydra is far from dead: on the contrary, like phishing, it continues to evolve.

If you've been keeping an eye on the threat landscape, you'll already know that it's been a long time since a ransomware attack "only" locked up your network and data, and demanded a ransom to get then back. A dual-threat tactic is now standard for most ransomware operators, where data is exfiltrated before the lockdown and used as additional leverage, with the threat that your sensitive data will be sold to other malicious parties, or published openly, if you don't pay. Indeed, some criminal gangs now focus almost exclusively on that aspect of the threat.

There's also a general trend in ransomware away from scattershot tactics and, again, towards highly targeted attacks. As mentioned already, phishing plays a central role in gaining initial access to the networks of the victim – in fact, this part of the attack is now almost exclusively carried out by affiliate operators working "on contract" to ransomware developers and owners. They do the donkey work of compromising the networks, stealing the data and blackmailing the victim using the malware provided by the owner. If ever you needed convincing that cybersecurity requires a holistic approach, this move to "ransomware-as-a-service" should be it.

TOP Old-fashioned hacking remains a constant threat

ABOVE Hardware security keys are an increasingly common form of malware defence

It's important to note that this new model of operation opens the threat vector to a broader church of criminals who don't need high-level tech skills to execute an attack. Everything, including initial access, can be bought if you have enough crypto to invest. Despite successful law-enforcement takedowns, the ransomware landscape is thus getting more, not less, complex, with more than 70 active ransomware groups operating globally.

In this situation, prevention is most definitely better than cure. If you do get hit, paying a ransom may actually be illegal, depending upon your jurisdiction and industry sector. Even if it's not, handing over the demanded funds is no guarantee that you'll get all your encrypted data back, or that the criminal gang won't sell your stolen data on anyway. To reduce the risk, the FBI recommends three basic cyber-hygiene measures, which all businesses should be following anyway:

1 **Install updates for operating systems, software and firmware as soon as they're released.**

2 **Require phishing-resistant, non-SMS-based multi-factor authentication.**

3 **Educate users to recognise and report phishing attempts.**

Multi-factor authentication bypass attacks

With the holistic approach to security in mind, we come to a third trend that you need to be aware of. Multi-factor authentication bypass (MFAB) is a specific avenue of attack that again has links to phishing, as it's another method of gaining initial access to your systems. However, MFAB isn't about stealing your username and password – the attacker may already have those, either from a previous phishing attack or from one of the many compromised credential databases available from underground criminal marketplaces.

Rather, as the name indicates, MFAB is designed to get around the multi-factor authentication methods you use precisely to defend against such a password compromise. At their simplest, these attacks redirect a user to a faked account page in order to get them to log in; they then trigger a valid 2FA request from the real site, forward it to the victim, and intercept their response. The attacker can then use this to access the service as a fully authenticated account.

Educational defences are sadly not likely to save you here: if the victim has fallen victim to the initial phishing or malware compromise then they're already in danger. But you can defeat such attacks by using multi-factor authentication methods that can't be intercepted, such as hardware security keys or virtual passkeys stored on the user's device.

This is why online sites and services are increasingly offering passkey login, and browsers such as Chrome and Safari also now employ app-bound encryption and keychain protections respectively. These encrypt data tied to identity, so that even if an application is running as the logged-in user it can't gain access to "secrets" such as session cookies.

Supply-chain attacks

We've talked about updating your security protections, but what about those of your partners? Supply-chain attacks are another rising trend that can't be ignored in 2025. In this type of attack, threat actors exploit vulnerabilities in one company's systems to gain access to another's, such as by embedding malware in their products.

This is another reason why even small businesses can't be complacent about security. Even if your own assets are of little value to the attacker, you could be targeted as a route into a bigger prey. Larger organisations, meanwhile, have to be alert to dangers coming not only from unknown outsiders, but also from their closest partners.

Supply-chain attacks are too often overlooked by small and medium-sized businesses. After all, you have enough on your hands worrying about your own security without having to worry about someone else's, right? At the very least though you can manage your liability and exposure by having strict cybersecurity standards written into your contracts with suppliers.

Domain hijacking

It's not always the newest, most exciting threats that can cost your enterprise dearly. Veteran readers may remember the five-year legal battle over the appropriation of sex.com back in the mid-1990s, and while it's unlikely that a rival would try to take over and build a business off the back of your domain, a cybercriminal could use your good name to spread malware, or as a base for other malicious activity.

The most common way this can happen is when DNS settings are misconfigured, such as by domain servers pointing to the wrong authoritative name server. An attacker can use this to redirect anyone trying to access your website to a fake copy hosting any number of malicious exploits. The better the reputation of the domain to begin with, the more valuable the hijacked product and the profitability to the attacker.

Your own systems might not be affected by an attack like this, but the potential for reputational damage is huge, as is the loss of business and other repercussions of visitors being unable to reach you. Mitigation is as simple as it is obvious: ensure your domains are properly configured. ●

"Even if your own assets are of little value to the attacker, you could be targeted as a route into a bigger prey"

Post-quantum cryptography

Is all our sensitive data about to be blown wide open? Steve Cassidy discovers how quantum changes the game

So what's the connection between quantum and cryptography?
Quantum computing is a tricky topic, but you can think of it like this: in a quantum computer, a single bit of data can represent both zero and one simultaneously. These magical registers are called qubits, and if you stack a lot of them together you can perform mathematical operations on millions of different values at once – and then use probabilistic analysis on the results to extract the answer you're looking for.

And the connection to code-breaking?
Many mainstream cryptographic systems are asymmetric. They rely on the fact that it's quick and easy for a computer to multiply two prime numbers together, but much more time-consuming to reverse the operation and find the prime factors of a given number. In fact, the fastest computers we have today would take trillions of years to crack a 2,048-bit RSA encryption key. Quantum computing changes the game: it's estimated that a quantum computer working with 20 million qubits could crack the same encryption key in just eight hours.

Is this a real problem? Does anyone actually have a quantum computer that powerful?
Right now, the biggest quantum computer in the world is IBM's Condor, which comprises 1,121 qubits – so you don't need to panic just yet. However, the field is advancing quickly, and cloud-based quantum services are already widely available from Amazon, IBM, Microsoft and others. Computer scientists live in anticipation of "Q-day" (flippantly known as "Y2Q"), when quantum computing reaches the point that existing asymmetric cryptographic methods are effectively useless. Some attackers are already preparing for that day by stockpiling stolen data that can't currently be decrypted, but which could one day be broken open to reveal valuable secrets.

Read our report from 2024's media event held at IBM Research Europe on p14

So should we work on the basis that cryptography is already dead?
Things aren't quite that bad. While cryptographic algorithms that rely on asymmetry are on their way out, there are other approaches that are much less susceptible to quantum cracking. One such model is symmetric encryption, as used by the AES algorithm. This encodes and decodes data using an arbitrary key that can't be mathematically derived, so attackers can't use quantum computing to help them break it. However, symmetrical encryption introduces the new challenge of finding a secure way of exchanging the encryption keys.

And research is ongoing into other quantum-resistant mathematical methods that could replace today's widely used algorithms, such as lattice- and hash-based cryptography. Quantum-proof encryption is already built into some popular tools that emphasise security and privacy, such as iMessage, Signal and NordVPN, and is becoming more widespread.

How can I be sure that I'm using an encryption system that's not quantum-vulnerable?
There's no easy way to verify for yourself that a given algorithm won't be vulnerable to quantum cracking in the future, but you can get some reassurance by keeping an eye on big businesses such as banks and tech giants. When they abandon an encryption standard, you'll know the danger is real. And it's a good bet that whatever system they move to will be safe from quantum attacks, because they have the resources to verify that for themselves – and every incentive to get it right. ●

Quantum jargon

Qubit: A unit in a quantum system that's capable of having a value of zero or one – or both values at once. The term is also used to refer to a physical particle that expresses this value, such as an electron or a photon whose spin or polarity can be used to encode binary data.

QRNG: Although quantum mechanics creates problems for some forms of cryptography, it also enables the creation of a Quantum Random Number Generator – a device that uses the chaos of quantum effects to create truly random numbers. This can be a valuable resource for security purposes, as the sequence is impossible to predict.

HNDL: "Harvest Now, Decrypt Later" – the chilling modus operandi of sucking up encrypted data today, in the expectation that it will be possible to crack it in the future with quantum computing. Though a real threat, the resources required mean this is more likely to be a nation-state activity than a regular hack.

NIST IR 8413: A report by the US National Institute of Standards and Technology detailing the ongoing process of selecting quantum-proof methods of encryption to be adopted as national standards. If you're familiar with advanced mathematics and cryptographic algorithms, you can read the report for yourself at **tinyurl.com/365nistir**.

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Real world computing

Expert advice from our panel of professionals

JON HONEYBALL

"Being able to log in to your cloud VM session from a generic piece of hardware is a dream for IT managers"

Why Microsoft's new mini PC isn't a bad deal, a reader rides to the rescue and a slow "exodi" from two of the world's biggest social media platforms

As we slide into a new year, it's always good to take stock of how we do things, and whether they're actually best aligned with our needs.

Let's start in the enterprise space, because there are changes happening here that are hard to ignore. These days, corporates love to run their normal line of business applications on Azure and to use Office 365 as a standard platform. Some services can be hosted on other platforms, notably AWS, especially for tools provided by a third party. But Azure has built up very strong traction, and the deep integration with Office 365 can't be ignored.

Windows, as a desktop platform, has been brought into this realm by the deployment and management tools that Microsoft offers. And it really is almost a no-brainer for those companies that want Office 365, Teams, Outlook and so forth in a wholly managed environment.

The chink in the armour has always been Windows itself. About a year ago, I looked at the new cloud-hosted Windows 365 offering, where you can run your Windows session on a cloud server. I ran it for some months, and it was incredibly easy to use and configure. At the time it was Windows 10, but Windows 11 has come along in the meantime. You simply choose the size of virtual machine you need (CPUs, RAM, storage) and it's built on the fly for you. There's no "shut down" per se, but the VM is put into hibernation when you aren't connected to it. It's "just there" when you do. And Microsoft is responsible for keeping it updated, managed and so forth, with you applying your policy settings through the usual Office 365-style portal.

Although useful, I wasn't using it on a day-to-day basis, so I shut it down, knowing I could revive the capability in minutes if required. Running it from a browser or RDP client is simple enough, but still feels like you're wallpapering the hallway via the letterbox.

So the announcement that Microsoft has a dedicated desktop computing box to support this function is very interesting. Called Windows 365 Link, it's been announced but not yet shipped. It's a small desktop box into which you connect screen, mouse, keyboard and network. It runs a heavily locked down version of Windows, and can't run apps locally. The OS is there to allow it to boot and connect. When connected to a Windows 365 cloud virtual machine, it operates just like a normal computer.

And of course it's fully integrated with Intune, Entra and all the other enterprise-level tools that are in the 365 platform.

Being able to log in to your cloud VM session from a generic piece of hardware, and for this to be fully locked down, is a dream for corporate IT managers, especially those who have an estate of hardware to manage. It won't be so good for weird configurations or app installations, but given that a huge swathe of such users are running Office 365 and apps that run in a browser, the simplicity is going to be a big hit.

Jon is the MD of an IT consultancy that specialises in testing and deploying kit
@jonhoneyball

"If I were an IT manager with an office full of ageing PCs, this would be a very tempting offer"

The pricing is not outrageous at around $349. Somewhat more than a Raspberry Pi, but then you're getting a box that, itself, will be part of the managed estate. If I were an IT manager with an office full of ageing desktop PCs, and we as a company were all-in on the Microsoft platform, then this would be a very tempting offer indeed. You might think this is a full return of computing to the cloud, including desktops, in an almost mainframe fashion, but that sort of chat requires beer. For the larger organisations, including those who hotdesk, this is going to be appealing.

Of course, some people need to work on the move. Connecting to a remote cloud virtual machine is going to be difficult on the 7.50am from Esher, because of the unreliable nature of the connection. For these users, keeping a local installation of Windows, along with the data, is going to be key, although this might well focus on locally cached email and Teams, rather than cloud-hosted line of business applications that need a more stable connection.

BELOW The Windows 365 Link could be of great interest to IT managers

Jon Honeyball
Opinion on Windows, Apple and everything in between – p108

Lee Grant
Tales from the front line of computer repair – p111

Olivia Whitcroft
Lawyer Olivia offers legal advice for the tech industry – p116

Davey Winder
Keeping small businesses safe since 1997 – p118

Steve Cassidy
The wider vision on cloud and infrastructure – p122

For the smaller enterprise, both of these solutions will work very well, and Office 365 remains the reigning king for such work. However, Google is still pushing its corporate platform, and I know several organisations that swear by it.

At the small business and personal space, there are interesting choices to be made. You can have an Office 365 installation, and use OneDrive to hold your data, and cloud Exchange Server to hold email. But you're lacking the sort of infrastructure help that comes from a corporate IT department, with both the skills and funding to ensure that things won't go wrong and, when they do, that they can be fixed.

I am still a big advocate of a local server such as a Synology, which you can use as a hub of data storage and replication, both for files and also for your Office 365 cloud data (emails, OneDrive and so forth). Not having this, and relying on a tired installation of Dropbox, might seem a little too risky. Cloud services are fine until something bad happens, and you discover that all your data is actually "over there" and the gates are locked. Not many hundreds of pounds buys you a very capable NAS that can keep your email, calendars, files and so on safely stored away, and why wouldn't you want that?

Let's turn to the true mobile platform. I know I'm old-fashioned when I say that I viscerally dislike the use of employees' own equipment for business purposes. It's entirely understandable why remote management is required by the organisation, but mixing home and work like this isn't a good idea. It isn't getting any better, and the potential regulations limiting out-of-office work and contact will make this even more apparent. Just hand out fully managed work phones and keep things simple.

A month of exodi

I guess the plural of exodus is exodi? Although that doesn't seem to please the spull chucker, it will do for now.

Nevertheless, it's time to move on. First, from Twitter. My experiment with paying for the blue tick on Twitter is coming to an end. Yes, I have no adverts any more, but the reality is inescapable – the "For You" feed is a cesspit of ranting nonsense. My "Following" feed is a lot better, but I have been noticing quite a lot of people leaving, saying they've had enough. I don't blame them. I know that when I stop paying, my "Following" feed will revert to its previous 50% useful, 50% garbage adverts, but that's fine. It's taken remarkably few moves to push me to rehydrating my Bluesky account. And, for the moment, that's where I'm going for my real-time news feeds. Over there, it feels like the early days of Twitter, and maybe it too will sink into the slime just as Twitter did, even before Elon took over. But his arrival has undoubtedly hastened the rot.

I won't be giving up on Twitter for the time being, but I have downloaded my history for posterity, and then I will go about using some third-party tool to delete it, although I keep hearing bad things about such services. It appears that Twitter wants to use my postings to feed its AI training engine, and I'm not happy with that. As part of the lock down, I have enabled "Protect your posts" so my posts are now only visible to those who already follow me. And I will be going through that list and having a thorough prune, because I know there are bot accounts there. Turning on "protect your posts" also prevents Twitter from using my future posts to train its engine.

ABOVE The Windows 365 Link includes all the ports you're likely to need

"Twitter wants to use my postings to feed its AI training engine, and I'm not happy"

So it's not over, but it's pushed into the weeds for the time being. I'll still read it, but I'm actively looking for alternative feeds from those sources that I enjoy engaging with.

Fortunately, they're popping up on Bluesky at a rapid rate, and that platform is experiencing a huge increase in utilisation. I also like that users can recommend lists of people to follow, and you can then browse through the list and follow some or all of them with a few mouse clicks.

Bluesky is limited to 300 characters or so, but this is no great hardship. I rarely read long-form posts on Twitter anyway.

So that's the first of my exodi. The next is Facebook. Now I know I originally said I wouldn't go there, but it has been incredibly useful to get in touch with various friends and acquaintances. However, I've always kept that account heavily locked down. What my friends and I are doing is setting up groups on WhatsApp. There really isn't much of importance that I can't do on WA that I could do on Facebook. And that too has turned into a cesspit of random advertising. Just like Twitter, the algorithm seems far more scattergun than usefully targeted, and

BELOW Elon Musk has hastened the exodus from Twitter to Bluesky

the recent changes to the Chrome browser platform means that a raft of useful Facebook filter tools really don't work any more – and have never worked on mobile. Like Twitter, I'm not going to leave Facebook, but will keep it as a secondary platform for contact with those other friends.

This isn't the first time that this merry band have packed up and moved camp. Many of us started out in the early 1990s on CIX, even before the internet became mainstream. And we've been on CIX, IRC and other places before ending up on Twitter and Facebook. The next wave is Bluesky and WhatsApp, and there's a reassuring feeling to making the move.

Crashing Synology

One of my older Synology NAS drives has an external Synology drive cage that holds a bunch of hard disks. Since it would be stupid to have one volume across both the internal and external disks, there are two separate volumes. And I'm getting reports from the system that the external drive cage has crashed, taking out all the disks held within. Fortunately, a reboot was all that was needed to bring things back to normal, but I suspect this is time to pension off the box to a much lower-priority task. It's the best part of ten years old now anyway, and that's too long to be good for front-line use.

Of course, I was lucky that the crashing volume didn't seriously ruin my afternoon. Or actually, not lucky at all – because it's part of a multi-machine setup that's distributed over three physical buildings. And has cloud backup to two different services. And it isn't the primary server anyway. Because of that, I can just say "meh" and move on. Could you do the same?

MagSafe charging

Last month I covered my disappointments with Quad Lock and its charging on iPhones, due to its 7.5W limit. I've found an in-car mount which at least does 15W. But thanks to reader Mark Goossens for telling me about Brodit (**brodit.co.uk**), which sells a wide range of mounts and clips and should allow me to use the 25W-capable MagSafe mounting. He sent me a photo of the mounting in his Caterham, above, so clearly he is a gentleman of good taste.

LEFT Mark Goossens takes full advantage of Brodit's mounts in his Caterham

Having gone to Brodit's website, it's evident the company has just what I need. And once I was looking there, I remembered that I'd seen this vendor before. So now I'm kicking myself that my memory let me down.

I am going to dive into its site and find the necessary pieces, and upgrade. Having asked around, Brodit gets a universal thumbs up, so it appears to be the go-to place.

VMware's free for all

VMware has decided to make its macOS Fusion and Windows desktop virtualisation platform free for all users. Earlier in the year it made it free for home users, but still paid-for for business users, but now it's free for all. Of course, this puts it at a significant competitive edge compared to Parallels, which costs quite a lot per seat per year. However, I note that it has dropped its price to £67.49 from £89.99 for the standard edition, and to £74.99 down from £99.99 for the Pro edition. So it looks like competition is good for all.

"I can just say 'meh' and move on. Could you do the same?"

Meanwhile, I keep hearing of larger enterprises that are looking to exit their VMware installations. The word on the street is that Broadcom has cranked up the licensing cost, and VMware isn't the only game in town in that sort of app management and virtualisation.

In the meantime, I'd recommend grabbing Fusion or the Windows client from VMware, and use that. It's a super way of running Windows apps on a Mac, or running Windows apps on Windows but in a fully contained platform.

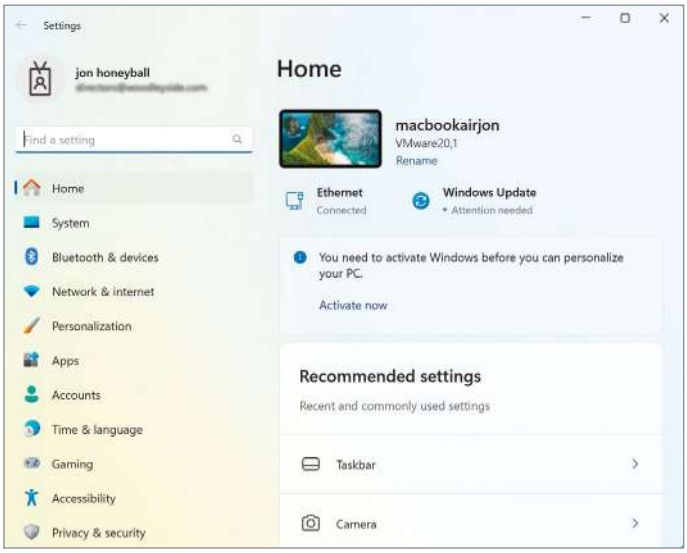
How frequent is frequent enough for updates?

This is a good discussion for a pint at the pub. How often do you want to receive updates for your applications? I think we would agree that, in most cases, having automatic updating is a good idea, because the rise of zero-day exploits means that the potential exposure of not updating must be weighed against a bad update being installed for you.

For myself, I update quite religiously, but I've made sure that I have other routes to my data and services if this particular piece of hardware dies.

It's instructive to look at the Google Play Store and the Apple App Store to see how frequently vendors update their apps. Many companies do it regularly, often several times a month. For some categories, this isn't actually to fix bugs or add new features for your particular device, but to add in capabilities for newly released hardware. In this case, the app is actually a shell platform into which "personality" pieces are inserted – look at the way Wi-Fi and security camera apps work here. A new piece of hardware is released, and an app update is required to support it. So this is sent out, even though it might not make any impact on your particular installation.

So how long is too long to have an update? When I'm looking at a new platform or tool, I always check the app stores and see whether the



BELOW VMware is now free for business users as well as home users

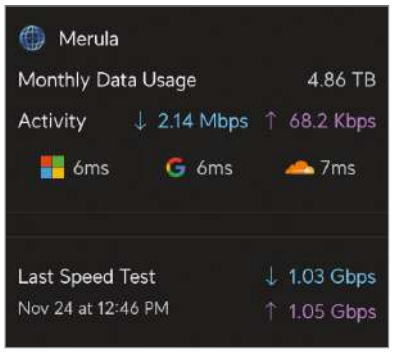
app is from the vendor itself, or is some bought-in third-party tool, which is usually enough to wave a big red flag. Then I check the updated date, and if it's more than six months, I start to get concerned. More than a year, and I'm twitchy. Any more than that, and I walk away.

Although there might be no new features to release, and no significant security bugs to address, the development platforms for iOS and Android apps moves forward. Apple is especially aggressive at pushing developers to keep up to date. So an ageing app might point to developer malaise, which then turns into customer dissatisfaction. Always make app updating part of your decision criteria for new apps, hardware and services.

The same thinking applies to firmware. Is there a firmware download capability? Is it automatic? What's the current version, and can you see a history on the support section of the vendor's website? If there are no updates, or it's three years old, then ask yourself why.

Monthly internet usage

Just checked the usage statistics on the internet connection at home. This has a primary line of 1GbE fibre from Gigaclear, and a Starlink satellite connection for fail-over backup.



ABOVE 4.86TB of data in a month is perfectly normal, isn't it?

It seems that in the past three weeks, I've used 4.2GB of data on the Starlink connection when the primary line has been down. And a whopping 4.86TB of data on the fibre.

I assume this isn't unusual? I'm asking for a friend...

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LEE GRANT

"Someone at Microsoft is making decisions that are turning my customers pretzel-shaped"

After revealing the inner workings of a secretive Microsoft department, we explain how you – yes, you! – can become a repair hero in 2025

Deep inside Microsoft's corporate strata, overseeing products for home users, is the Department (of) Overzealous Random Knob Switchers (DORKS). It's a department so secretive that Microsoft will deny that it even exists. For legal reasons, I also have to admit that I've made it up, but someone at Microsoft is making ridiculous decisions that are turning my customers pretzel-shaped. Until Microsoft is prepared to put its hand up and say "it's our fault", then I'll have to continue blame the non-existent DORKS at Microsoft.

Lee Grant and his wife have run a repair shop in West Yorkshire for over 20 years
@userfriendlypc

OneDrive to enrage them all

Carla is a good person. She's a key player in the local volunteer group, giving her free time to make the community a better place. But she isn't a tech person. When her entire library of charity and policy documents became inaccessible from her laptop... well, you can imagine.

Carla's setup isn't complicated. A Windows 11 laptop with Word and Excel 2010. At some point, probably during a Windows update, Carla inadvertently clicked to let OneDrive manage her desktop, documents and photos. She had no memory of doing this, nor did she know what OneDrive is. Regular readers may recall that I've spoken about this phenomenon in previous issues.

> "One innocent click fires user data into the cloud without the customer realising"

BELOW Messages about storage being full can be confusing to the unaware

The DORKS at Microsoft should be congratulated for this Penn and Teller calibre sleight of hand. One innocent click fires user data into the cloud without the customer realising. If you're thinking that Carla should be more aware and read the information Microsoft puts on the screen to explain what's about to happen, then you have a point. However, for the millions that don't understand the terminology, the keep-clicking-until-it-goes-away technique usually results in a Microsoft-positive outcome. The DORKS at Microsoft have loaded the system so declining the service is tougher than accepting.

The question is: why? Is Microsoft using OneDrive data to feed Copilot? It says no, but the Mozilla Foundation is asking for clarity. Its petition (**tinyurl.com/365mozilla**) states: "We had four lawyers, three privacy experts and two campaigners look at Microsoft's new Service Agreement, and none of our experts could tell if Microsoft plans on using your personal data." AI-fuelling debate aside, the other benefit to Microsoft is old-fashioned cash-grab subscriptions.

After the switcheroo, Carla saw red crosses next to her files. These represent sync errors, but could mean anything to the unaware. Carla then started receiving messages about "drive full", so she panicked and began clearing out files.

For clarity, Carla's laptop has a 500GB SSD with around 400GB free. There was no need to delete files, but the messages she misunderstood was OneDrive bleating that she'd filled her complimentary 5GB of space. Disaster finally struck when she accidentally deleted the wrong files.

For you, learned *PC Pro* reader, the fix is simple. OneDrive flagged that a number of files had been removed, giving restoration options. I clicked and the files returned. OneDrive isn't a terrible system, but the way the DORKS at Microsoft have implemented storage balancing is mystifying. This was the root of Carla's chaos.

Carla's Hotmail account gives her 5GB of OneDrive space, which Microsoft had graciously allowed to overspill to 6GB and was offering subscriptions to increase capacity. However, the content of OneDrive wasn't the problem.

Another clue: Carla's Hotmail email was holding 4.7GB out of her Hotmail allowance of 15GB. Can you spot the problem? Carla couldn't, and it's no wonder.

Some time ago, Microsoft linked user email storage to OneDrive (*see issue 351, p113 for more on this*). Carla's 4.7GB of (mainly) attachments is tallied against her 5GB OneDrive allowance, not her 15GB of email storage. Carla's OneDrive is full, not because of her documents or photos, but because she has a lot of email attachments. Despite having over 10GB of free capacity in her email allowance, she's been snared in a booby-trapped system. In addition, Carla accesses this email on her phone and hadn't spotted Microsoft's warning that unless she cleared the 5GB blockage, her email would stop in 16 days.

So, in short, OneDrive is blocked because of Hotmail and Hotmail will stop working because of OneDrive. Nice work, DORKS!

I couldn't fix Carla's problem in the traditional sense of offering a complete solution. Deleting email is not a task I usually get involved with. Although I'm often asked to tidy up data stores, I explain it's akin to asking me to clear out a customer's wardrobe. I may get most of it right, but there's a risk I may throw out a prized cravat. I made suggestions as to what Carla should do next and switched off OneDrive's photo sync to stop the nagging. The UI's file storage declared that Carla was now only using 2.5GB of 5GB. Her Microsoft account disagreed, maintaining the 6GB overspend and a threat to turn off email. OneDrive: three (different) used-data metrics, two storage allocations, one confused user.

Officially, Microsoft is helping its users to back up files. I'd argue that, at best, it's synchronisation with a safety net. It's better than no backup and, historically, Microsoft's built-in backup solutions have always been poor. Aside from OneDrive, the (increasingly hard to find) Windows System Backup on Windows 11 is the same 2009 Windows 7 utility.

An often overlooked facet of the "don't pay for antivirus" debate is the additional facilities many AV packages offer. One of Norton's USPs is its simple USB backup solution. Today, for the customers that request it, Norton USB backup is a simple two-click process.

2024's DVD extras

Before the inevitable anticipointment of the New Year kicks in, I need to empty the story vault from 2024. Here are some repair shorts from the past 12 months that, for various reasons, didn't make it to *PC Pro*.

I'm always encouraged when people try repair. From a business point of view, this could be seen as corporate suicide, but the bigger picture is more important. Simply put: for the sake of the environment, we need to fix more stuff.

Ivor had never fixed a laptop. He inadvertently slipped into repair's jeopardy pit by starting with one fault and ending with two.

His small HP laptop was overheating. One gotcha with thin Ultrabooks is that by the time the design team has forced a normal laptop through a kitchen mangle, there isn't much room left to add decent cooling fans. Ultrabook cooling fans are slim and sufficient for the task, but it doesn't take much debris to block them. Ivor's laptop kept shutting down because the blocked fan was tripping the thermal cutout. Ivor opened it up, cleaned the fan, replaced the lid and found the machine would only stay powered on for about three seconds.

ABOVE **The Ultrabook was shorting due to a missing screw**

When he brought it in, I mentioned that there was a screw missing from the underside. I didn't intend to criticise, but it's good practice to note anomalies when a machine comes into my possession. It's the standard hire-car scenario. Ivor placed the missing screw onto the counter, saying that he couldn't get it to fit.

"Ivor slipped into repair's jeopardy pit by starting with one fault and ending with two"

This narrative's unsubtle Chekhov's gun caused the fault. One environmental issue that many technology manufacturers are slow to address is the plastic composition of their products. As Ivor's Ultrabook had been overheating, the hinge plastics had become brittle. During the fan clean, the brittle plastic broke off, then shifted. By some fluke, this fragment contained the brass bush that the screw fits inside (hence why he couldn't refit the last screw), and it had slid over the power button's connections, shorting them.

A dab of glue and Ivor's laptop was back on, with a full complement of screws.

I SAID, SILENT COMPUTING!

In the same vein, when I'm brought a desktop, I pick it up and give it a gentle shake. Many of them rattle because a retaining screw made a break for freedom, but not like Suzy's. It really rattled. It also wouldn't boot.

Suzy, by her own admission, is hard of hearing. She struggled to tell when her PC was switched on and became worried about it overheating. Her ingenious solution was to change the cooling profiles of the CPU fan from Smart to ALWAYS MAXIMUM POWER!

Once on the bench, Suzy's machine reminded me of my Mum's old Zanussi washing machine, which used to walk across the kitchen floor during the spin cycle. The reason her PC wouldn't boot was that the SSD had fallen to bits. The drive luckily survived.

BELOW **Quiet life: the SSD that fell to pieces after the CPU fan was set to max power**

During further noodling, I also spotted that the genius who had built the machine bodged the wiring for the case LEDs, so they didn't work. Corrections complete, Suzy could easily check the machine. I turned the fan profile back from "AAAARRRGGHHH!" to "Sssh!".

Auto-schematic for the people

Recently I was fortunate enough to attend the *PC Pro* awards, where the winners that you vote for receive the highest technical accolade money can't buy. It's an amazing occasion, and I don't mind sharing with you that I'm like a fish out of water.

"What do you do?" said a lovely lady.

"I repair things," was my not untrue reply and, as has happened so many times before, the conversation was killed dead. Tech companies are keen to talk about their commitment to sustainability and repair, but I've found that they're not always eager to do this with me. Things get eggy when I bring up the subject of schematics.

For the uninitiated, schematics are maps of the electrical systems in a device. They detail the paths that connect resistors, capacitors and ICs together. More usefully, they show the properties of a component, and this is invaluable information. Due to miniaturisation, many components are unmarked. We'll let Donna's monitor demonstrate why this information is important.

Donna's monitor was also suffering power problems. One night, the monitor powered off and then refused to power up. Subsequent pushes of the power-button glowed (as it should) but nothing usable happened.

Once I'd broken it apart, I managed to remove two power boards. One was "high side", which converts mains-power 240V to a much lower voltage, and is pushed around by the "low side" board.

Donna's description of the fault led me to think that there may be a problem with the capacitors, components that store and release voltage on demand. The power boards were fitted with through-hole barrel capacitors, so the repair process began with testing these. Although this is possible with a multimeter, I have an ESR meter made by Peak Electronic Design in Derbyshire (**tinyurl.com/365peak**). Not only will it give a capacitance measurement, but it will discharge the stored electricity inside the capacitor should it need to be removed. This is a useful feature as it helps to keep the repairer alive.

Several of the capacitors were faulty. How did I know? The ESR meter gave a reading that I could check against the rating stamped on the side of the component. Through-hole barrel capacitors are large enough to have this vital information, but the surface-mounted versions (SMCs) in our laptops and smaller electronics do not. Therefore schematics are critical in the repair process. If Donna's monitor had used SMCs, I couldn't have repaired it as I'd have no idea of the correct capacitor rating to use. SMCs are a bit like spectacles. Although one pair looks identical to another, it's the lens properties that determine if they're going to be fit for purpose.

As a precaution, I replaced all the ageing capacitors on the board and Donna's monitor powered on.

How much worse can I make it?

Though I don't advertise services of general electrical repair, I'm often brought non-PC devices. In the last year I've fixed DVD players, USB lights, set-top boxes and many children's toys. Ironically, the servicing department for a local car dealer – a global premium brand – can't fix its bespoke diagnostic equipment when its mechanics break the connection ports. This manufacturer, portfolio dripping with green/environmental commitment, refuses to repair the "unrepairable unit", preferring to sell a £6K replacement, ordering the dealership to "bin the broken one".

ABOVE Two power boards were removed from a monitor that wouldn't power on

"In the last year I've fixed DVD players, USB lights, set-top boxes and many children's toys"

BELOW Through-hole barrel capacitors are large enough to have useful info on them

When the servicing manager asked if I'd take a look, I agreed on the understanding that I may not be successful. But on the other hand, how much worse can it get? I succeeded and, several times a year, a car that cost more than my house pulls up outside the shop with another "unrepairable" box.

Now it's your turn...

So here's your homework for 2025. First, please keep supporting *PC Pro*. Treat yourself or your techie friend to a gift subscription from **tinyurl.com/365subscribe** or telephone 0330 333 1113 (ask for Babs!). Second, subscribe, listen and rate the award-dodging *PC Pro* podcast (**tinyurl.com/365propod**), which will have been on air for 18 years in April 2025. Also, drop in for a friendly chat with other readers and writers of the mag on Discord (**pcpro.link/discord**).

Finally, fix more things. It doesn't have to be laptops; start with squeaky hinges or missing buttons. If you're a bit more experienced, then find your local repair café and offer an hour (or more) of your time (**tinyurl.com/365repaircafe**). I know from the readers that reach out to me each month that skills and experience are sitting dormant. In the Open Repair Alliance's recent report about the social benefit of community repair (**tinyurl.com/365repair**), Martine Postma from Repair Café International says: "For repairers, a reason may be to meet new people from the community, to share their skills, to stay active after retirement, to be a valued member of society, to learn from other repairers, to exchange skills, to have a good time. There are multiple reasons for starting or visiting or participating in a Repair Café." So, in 2025, get out there and help to fix something.

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OLIVIA WHITCROFT

"The questioner and I were in the virtual room alone together. Or were we?"

We all have an implicit understanding of what "confidential" means, but in practice it's open to misunderstanding – fortunately, the law can help

I was taken by surprise on Teams the other day with the question: "Please may I speak to you about a confidential matter?" As a solicitor, one of my professional duties is to keep the affairs of my clients confidential, and I am used to confidential discussions. So the request itself was not unusual. The surprising factor was that it was being asked in a meeting attended by 20 people.

It was during a break in a training course, and I was sharing a picture of a cup of tea. The other delegates had their cameras and mics switched off, so presumably had retired to their real kitchens to enjoy a real cup of tea. The questioner and I were in the virtual room alone together. Or were we? Maybe some of the other delegates were forgoing their hot beverage and were instead lurking in the background listening. Perhaps some had taken their laptops with them to the kitchen. Maybe some worked in an old-fashioned office and were broadcasting the session to colleagues.

I said that this was perhaps not the best environment for such a discussion, but that I would be happy to speak about it after the meeting.

It got me thinking: what environments are suitable for confidential discussions, and how can I meet my duties of confidentiality?

Keeping it confidential

What better place to clarify my obligations of confidentiality than the guidance from the Solicitors Regulation Authority (SRA)? "This duty of confidentiality exists as an obligation under both common law and data protection legislation as well as being one of the core professional principles set out in section 1(3)(e) of the Legal Services Act 2007 and professional standards in our Codes." Okay, so not just a gentle "You must keep things confidential as it's in our Code of Conduct", but "You must keep things confidential – it's in two statutes, we've put it in our Code, and don't forget common law, too".

Olivia is principal of the law firm OBEP, which specialises in technology contracts, IP and data protection
@ObepOlivia

"A lot of records I hold may be not just confidential, but privileged"

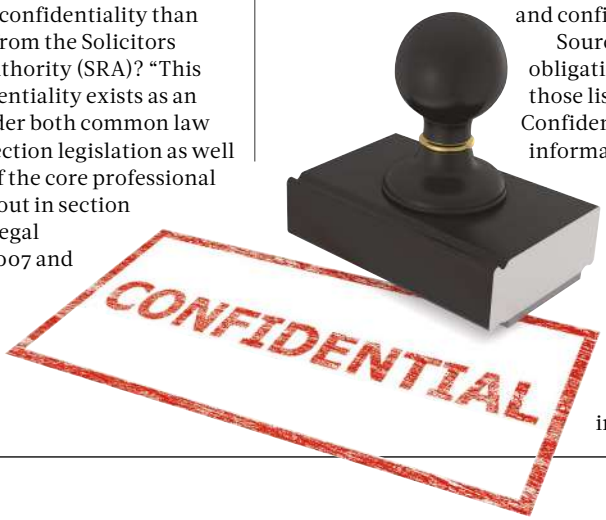
I read on.

"…Note the need to distinguish… professional obligations of confidentiality from… legal professional privilege… confidential information may be disclosed where it is appropriate to do so but privilege is absolute, and privileged information cannot therefore be disclosed."

Goodness me, there's another layer. A lot of records I hold may be not just confidential, but privileged, which means they need to be kept even more confidential.

"Good luck, Olivia", you may think, rubbing your hands together in glee that you went down a different career path. But "ha ha!" I say, as other professions also have duties of confidentiality under common law and codes of ethics, such as doctors to patients, accountants to clients, and directors to their companies. And data protection legislation doesn't just apply to me, which is fortunate for my career as a data protection lawyer. All UK organisations handling personal data are subject to the UK GDPR, which is riddled with references to confidentiality. There's even a whole principle named after it: the "integrity and confidentiality" principle.

Sources of confidentiality obligations aren't limited to those listed in the SRA guidance. Confidentiality is a pillar of information security, just as information security is an important part of maintaining confidentiality. Statutory and regulatory rules on information security apply to organisations in many sectors, including financial services, communications, critical infrastructure and digital services.



BELOW **Don't label all your records as confidential or it will lose its meaning**

Now let's add contractual confidentiality obligations within non-disclosure agreements (NDAs) or as part of services or settlement agreements. Contracts may require adherence to security standards, such as ISO27001 and Cyber Essentials. Sometimes a duty of confidentiality may be implied, such as within employment contracts.

Where there is no contract, we can look to common law and action for breach of confidence. This arises where information has the necessary quality of confidence (including not being widely known), it is shared in circumstances indicating an obligation of confidence (such as "Please don't tell anyone else about this") and it is used without authority to the detriment of the person who shared it (for example, published online causing financial loss). This has close links with other laws protecting confidentiality, such as trade secrets regulations, the tort of misuse of private information, and human rights laws (including the right to respect for a private life).

And in the unlikely event you're never subject to any of these, consider the wider business drivers to keep information confidential: staying competitive, maintaining good relationships and protecting intellectual property, to name a few.

So thank you for your good luck wishes. Good luck to you, too.

Weighing up the risks

As is clear, the legal need to maintain confidentiality arises from a variety of laws, codes and contracts. Trying to analyse the different rules and how to comply with each one separately is likely to get your head into a spin.

Let's look at the reason for having them to start with: to protect against the impacts of a loss of confidentiality. These may include financial and business losses, emotional or physical harm, discrimination and reputational damage. A loss of confidentiality for material protected by legal professional privilege may also prejudice a client's legal position.

In applying the rules, we're trying to minimise the risks of these consequences occurring. The precise nature and severity of the impact may vary depending on the type and scope of information, and who or what it relates to. The environment in which information is discussed, stored or used may affect the likelihood of the impact. Also bear in mind that if there

is a breach, it may be difficult to reel the information back in and re-instate its confidential status.

Take my Teams call again. When the questioner made their request, many factors whizzed through my head to assess the confidentiality risks. First, I didn't yet know the sensitivity of matter, but even if we stopped the discussion immediately after I found out, something confidential may already have been revealed.

There may have been 18 other people listening. The larger the group of people information is shared with, the higher the risks. None of them had agreed to keep content confidential and may not have even been aware of a need to. The meeting was a training session, so records may be used and shared with that purpose in mind.

The delegates were from a diverse range of organisations and locations, and I hadn't undertaken any checks on their reliability (or even that they were who they said they were). If they had all worked in the same place I may have had some assurance over their firm's confidentiality and security policies, but this wasn't the case here.

Risks in using the Teams platform also flashed through my mind. This was not just whether Microsoft has implemented appropriate technical security measures, but also whether I had sufficient understanding and control of the settings for the meeting. Would a recording of the meeting shortly be uploaded to the cloud?

All these factors fed into my conclusion that we should not have the discussion.

Labelling records

It may be tempting to rely on technology to address confidentiality risks. And yes, storing, using and communicating confidential information on systems with good security controls is an important step. However, as my example above shows, maintaining confidentiality is not just about the technological environment. We also need to consider the physical environment, the range of people involved, and their awareness and reliability.

It can be helpful to label records as confidential. This can assist with their legal protection, and those who access them will be aware that they need to be treated as such. But it is possible to go too far. I was advising a client that had decided to mark as confidential all records held by a particular department, to save time in going through them to determine which records were genuinely confidential in nature. However, they did not, in practice, treat all these records as confidential, as many of them were widely shared both internally and externally.

A concern was that the label of "confidential" had lost its intended meaning. If some records are regularly shared, that suggests it is acceptable to share all records with the same label. It would be preferable for the label to be applied only to genuinely confidential records, which may enhance their quality of confidence and clarify restrictions on access and sharing. If needed, a different label could be used to distinguish another layer of confidentiality, such as for records that are privileged.

Labelling records by reference to their permitted use can also assist. When I'm engaged by a client, they give me confidential information to provide them with legal advice. I would be risking that confidentiality were I to use the information for another purpose; let's say because it would make a good story for a Real World Computing column in a well-known technology magazine.

Contractual measures

I was reviewing a software development contract with a two-way confidentiality provision; each party had an obligation to keep confidential "Confidential Information" of the other party, and not use it for any purpose other than providing or receiving the services.

Confidential Information was defined along the lines of: "(i) all information about the software deliverables; (ii) business information, including product plans, know-how, and software; and (iii) any other information that is disclosed to the receiving party, which is designated by the disclosing party as confidential".

ABOVE Beware of confidentiality risks in videoconferencing meetings

"The larger the group of people information is shared with, the higher the risks"

My first concern: which party's "Confidential Information" is the information about software deliverables? If neither party is permitted to use it except in connection with its development, this might make it difficult to exploit the software in practice.

My second concern: the scope of information is so wide! The first two aren't limited to information that is confidential in nature, and "business information" could include anything. Then we have (iii), which mops up anything else that is designated as confidential. Does this mean that something labelled "confidential" must be treated as such, without the need for it to have a quality of confidence?

To add to the confusion, there was a provision requiring the receiving party to return all Confidential Information at the end of the agreement. Who is returning what to whom, and does the customer need to return the software it has just paid for? Even with clarity on this point, it would be problematic returning information needed for purposes such as invoicing and essential record-keeping.

My suggestion was that, rather than trying to interpret the practical impact of this poorly drafted provision, both parties would benefit from additional clarity to achieve what is intended: maintaining the confidentiality of genuinely confidential information.

BELOW Confidentiality agreements must be well drafted so obligations make practical sense

Unanswered questions

To my disappointment, the questioner from my Teams meeting never did get in touch to discuss their matter. On the upside, I suppose there's no risk of me breaching a duty of confidentiality for information I don't know. Perhaps they were worried I'd tell everyone about it in this column.

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DAVEY WINDER

"I know what it's like to fall victim to cybercrime. Even so-called professionals can get caught out"

Davey reveals one of the oddest cyberattacks yet and says that we all need to stop blaming users for cybersecurity failings

My name is Davey Winder and I have a mental health problem. For the past two years I have suffered from a chronic pain condition that has no cure. Perhaps unsurprisingly, then, I have also suffered from depression, which has been treated both by medication and primary psychiatric care.

I mention all of this not for the sympathy vote, but rather to demonstrate that our mental health is not something that we should be embarrassed by, be ashamed of, hide away from or not mention to anyone for fear of rejection or belittlement. Mental illness is an illness like any other, and a new report has revealed that victims of cybercrime are suffering their own mental health crisis. That report has even coined what I think could be a new word for the mental health issues cybercrime brings along for the ride: cyberstigma.

Before I dig into the report findings, that cyberstigma term needs looking at from a broader perspective as it reminds me how the cybersecurity profession – and that includes the media, so mea culpa here – often attributes blame in a very offhand and diminishing manner. Users are the weakest link. You shouldn't have used that password. Clicking that link started the network breach. Why didn't you know that was a phishing email?

Do you see where I'm coming from? Shifting or focusing blame onto an individual employee with no professional security training or certified skills, let alone being in a security professional role within the organisation, is applying that cyberstigma. Just because any or all of those statements might be true, post-breach the true cyber professional takes responsibility for their own failings, which would include failing to educate and protect those employees, as well as building bridges to improve detection and prevention in the future. We, as an industry, need to do better and stop playing the blame game where the goal is apparently to throw the "weakest link" under the bus. Seriously, with this attitude across so many organisations even today, it's no wonder the bad guys are winning.

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"Let's make an effort, be that at home or work, to quit with the blame culture"

With that rant out of the way, let's take a closer look at what the Akamai "It's time to talk about cyberstigma" research (**tinyurl.com/365stigma**) actually found. Produced in partnership with a psychologist, Dr Tara Quinn-Cirillo, the researchers questioned over 1,000 Brits who had been a victim of cybercrime during 2024. Cybercrime does a lot of heavy lifting as words go, but in the case of this research it included the likes of phishing, identity theft, phone hacking and ransomware. In other words, a broad sweep of the type of cybercrime that is most prevalent today.

I'm never totally convinced by the numbers that are thrown about in reports when it comes to the financial cost of an individual cybercrime incident, be that to a consumer or an organisation. There are so many variables and knock-on impacts to take into account that you can easily underestimate the true cost. Or, as is often the case when looking for that headline-creating impact, wildly overestimate it. However, when it came to asking those victims in the survey how much the incident had cost them, the amount averaged out to £808, which I can accept as a realistic figure from speaking to many victims of cybercrime over the years.

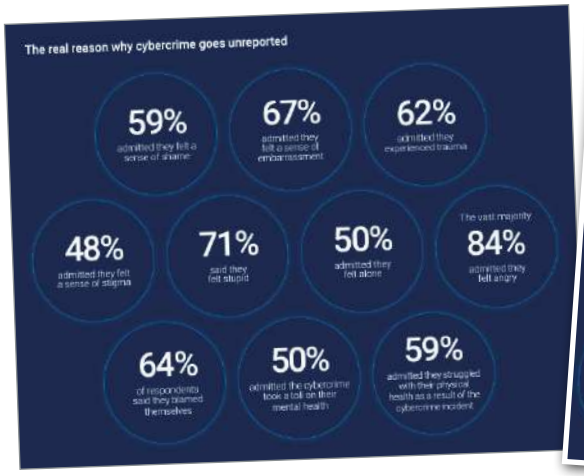
Given the economic landscape, I can also accept that 20% of those surveyed had experienced real financial hurt as a result, bills going unpaid or even food shopping having to be trimmed right back out of necessity. These are the very real and visible impacts of cybercrime on real people. Victims aren't just a statistic or, as one assumes the scumbags who perpetrate these crimes imagine, a username on a machine.

Mental health impact

The far less visible, and consequently far less well understood, impact is on mental health. Let's get the survey numbers out of the way: 62% of victims said that they were traumatised by what had happened to them, 67% admitted to feeling embarrassed, 59% admitted to feeling ashamed at falling victim, and 55% continued to experience anxiety while using online services after the crime was done and dusted. As a painsomniac, the fact that 29% also said they had trouble sleeping after the crime hits hard here.

The numbers regarding embarrassment and shame are reflected in the fact that 43% didn't tell anyone about their falling victim to cybercrime for fear of being judged, while 64% blamed themselves.

BELOW **A recent report has highlighted the effect cybercrime has on its victims**



Images: AKAMAI

I started with a confession, so I might as well throw another in towards the end: I know what it's like to fall victim to cybercrime. Yes, even so-called professionals can get caught out in moments of vulnerability. I didn't lose any money, but I did lose a certain amount of self-respect for falling for a stupid credentials attack that enabled someone to gain access to an account that, as luck would have it, was worth diddly squat to them. I discovered the incident quickly enough and was able to cut off their access before any real damage was done.

Did I blame myself rather than the attacker for targeting me? Yes. Did I feel ashamed and embarrassed about it? Yes. Did I tell anyone? No, you are the first, despite this happening over ten years ago now when I was struggling mentally following a rough divorce.

"Cybercrime can be devastating to an individual's mental wellbeing. As this research has shown, self-blame is common, and feeds into feelings of inadequacy that can be incredibly toxic," said Dr Quinn-Cirillo. One of the outcomes of the research was that victims said they felt a better, more open conversation about cybersecurity in the media (well, hello there!) can help in dealing with the aftermath of cybercrime. Let's make a concerted effort, be that at home or work, to quit with the blame culture and start accepting that threat actors are the villains here, not the victims.

Just when you thought cybercrime couldn't get any weirder...

When you've been writing about cybercrime for as long as I have, it's hard to get left-sided by any tactic employed by those who would do us harm. I've lived through hackers quite literally crawling around in skips looking for corporate information to use in a breach attempt; replacing the image of the then Spanish Prime Minister with a picture of Mr Bean on the EU presidency website; an Iranian nuclear facility being hacked so it was playing AC/DC's "Thunderstruck" at full volume; and even a cybercrimer who uploaded their own fingerprints to the crime scene in order to bypass a biometric lock.

ABOVE/LEFT AC/DC at a nuclear plant, crawling around in skips and hacked toothbrushes: all part of the weird world of cybercrime

I'm not finished yet. An employee stole servers from his own company and hid them under the floorboards of the data centre to mine crypto; and finally I'll throw in the hotly disputed tale of whether a botnet of three million smart toothbrushes was used to launch a distributed denial of service attack.

I mention all of the above for one simple reason: to highlight just how goddamn weird the threat actors in Switzerland are who have started a phishing attack using the post. Not email, oh no, but the post. You know, that thing we used to call "snail mail" before it all but disappeared up its own backside.

Switzerland has its own version of the UK's National Cyber Security Centre which is, rather confusingly, called the National Cyber Security Centre. The Swiss NCSC has taken to the ether – in the circumstances, I can't help but think a mass mailout would have been more appropriate – to warn citizens of a phasing campaign using the Swiss Post to send a cyberattack into their homes and offices.

Although weird, I wouldn't classify this particular attack methodology as being stupid. That's because it draws upon a well-stocked history of the physical being used to distribute the digital when it comes to malware campaigns. Loyal *PC Pro* readers will likely recall me warning about such things; specifically pavement hacking, where infected USB thumb drives were left discarded on coffee-shop tables or the pavements and car parks of a target office waiting to be picked up, and letting curiosity work its magic as the victim stuck the thing into a networked laptop.

This is kind of in the same vein. Send a letter, presumably targeted in some way (although the NCSC warning doesn't mention this), which includes a QR code that leads to a malicious download. That's the initial delivery methodology here, but the attackers need a way to get people to scan that code and make that download. They can't simply rely on the curiosity of the very odd person who would do such a thing, assuming they had opened this real-world bit of junk mail in the first place.

BELOW Victims were sent to a page designed to look like the official MeteoSwiss app

Misinformation, fakery and deception are the keys to the phisher kingdom, and are used to good effect in this attack. The letter itself purports to have been sent by MeteoSwiss, the Swiss Federal Office of Meteorology and Climatology, and contains details of a severe weather app that it encourages the recipient to download as a matter of some urgency for their own safety.

On scanning the QR code, they're presented with an app that's made

Continued from previous page

to look like the genuine Alertswiss government app from the Swiss Federal Office for Civil Protection. When they download this app, malware is installed; in this case the Coper credential stealer, and that sets to work looking for data from any of the more than 300 apps it recognises on the smartphone in question.

Although this campaign is aimed squarely at Swiss residents, obviously, and even then only those with Android smartphones, it isn't a huge stretch of the imagination to think that other threat actors will latch on to something similar and see the value in using physical distribution methods for their digital scams once more.

And finally...

I can't leave you this month, seeing as we are focusing on cyber-awareness and the methods used by threat actors of all shapes and sizes, without mentioning one attack campaign that has highlighted the dangers of holding down the Ctrl key. Yes, I know, how weird is that? Not too weird, it turns out.

Forget the method used to fool the victim in this phishing attack, it's all but irrelevant. The important part is that the clickable call to action used – you know, the bit where you end up being urged to click a "view document" or "open file" button – adds a seemingly odd request: "hold down the Ctrl key and click".

This, said the researchers from Perception Point security who brought this to my attention, is both a subtle and highly effective way to evade email security scanners and automated detection tools. It works, sometimes, because the defensive measures aren't looking for the additional layer of human interaction at this point. It's adding a behaviour that doesn't match what it's looking for.

I guess the lesson to be learned here, atop the one about clicking links and opening attachments that we're already aware of, is not to blindly obey instructions given in communications you weren't expecting. Especially ones that require you to do something totally out of the ordinary.

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STEVE CASSIDY

"Gritting your teeth now is going to be your last chance to make improvements"

If you're wondering why phone calls are still so difficult in 2025, Steve – grand master of the VoIP upgrade project – has some answers

Years before the pandemic so dramatically entered our lives, I was running two projects concerned with handling voice traffic. And they couldn't have been more different. In one case, creating a complete, parallel, enterprise-wide network just for the allegedly more modern, cost-saving, VoIP-based phones; in another, a wholesale conversion to computer-based telephony, with headphones and software replacing handsets and separate technology.

These dichotomies caught me on the hop. I had a modern nerd's attitude to voice, one that only revealed itself when I came to confront my own prejudices during the design process. Customer A wanted ultimate reliability; Customer B was happy with the reliability level it already had with its LAN and couldn't justify duplicating it "just for phone calls".

My belief was that telephony was on its way out, to shortly and inevitably be replaced by the already mature field of internet-carried videoconferencing. I was certain that the money available in company budgets for buying and keeping traditional internal phone systems would shortly be flowing my way through consultancy projects like the two mentioned above.

What lessons were available to learn for each customer, and what relevance do they retain now? Has much changed in the buying choices available to those of us straddling more than one technology sector while earning our daily bread?

The elephant in the room is the revolution in working practices brought about by Covid. Until then, old phones ruled. You see, they're comforting dumb tech. All those newer communication platforms such as Teams required a well-presented and internet-ready IT portfolio. PCs lagging behind in the update stakes? Teams would be the canary, letting you know that "something went wrong" but being no more specific than that. Some companies bit the bullet and nuked the messy old configurations on users' machines, preferring a clean start where communication was the highest priority. But most did the equivalent of a shrug of the shoulders and allowed workers to fall back to basics, meaning that dull traditional telephony remained on the menu for a lot of businesses.

Taking a longer view, what happened here was the opposite of a well-planned update project. Companies bodged to gain breathing space for the IT teams, who suddenly found themselves tangling with health restrictions that put staff out of their reach by any physical means. No wonder they stuck to tried and trusted solutions, creating a hash of VoIP and traditional phones.

I watched this hack-around process happening in several organisations and hated every last

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"I was certain that the money in company budgets would be flowing my way"

BELOW Teams is often the canary in the mine when it comes to hardware updates

second of it. Don't give up on the leading-edge fixes, guys, I thought: you'll find it so difficult to break free of whichever emergency setup you settle on. Gritting your teeth now, jumping far forward with your telephony, is going to be your last chance to make improvements for the next decade, or more.

At least in that regard, I believe I was right. We're still seeing the results of those mighty efforts and expedient decisions now. In one project I was obliged to design a side-by-side deployment, because the VoIP guys supplying all the phone hardware said they were wary of the nature of the traffic on the regular PC network as found at this business. We sat the PCs on a 192.168 network, the phones on a 10.x network.

This was all segregated, as required, with the phones going through their own server (a Mac Pro 5.1) to reach external SIP providers and thereby make and respond to calls. We had a separate architecture to support a multi-site VPN, with dedicated firewalls handling the routing of inter-site traffic, so that there was no need to add any routing information to PCs inside the offices.

Extending the separate phone network through this spiderweb of VPN links looked like it should have worked, but in reality it didn't. We had to present routing configurations not only to the server, but also to all the handsets likely to want to call one another. And we had to troubleshoot quirks such as phones ringing when called, but no sound being presented after they were picked up.

I ended up doing experiments on the other customer network with the greater use of PC-based softphones, and found that the more accessible and fully featured routing options on full-fat Windows laptops meant they kept working in little corners of the VPN structure where the trad-looking handsets wouldn't.

Voice concerns

In this case, it's hardly surprising to hear that home workers were quietly going back to consumer telephony. Which leaves us asking the question: what's been happening with boring old voice calling during and after the lockdown scramble?

It's got worse. A whole lot worse. It might be our fault, too. Subsequent releases of software and whole new classes of hardware have already shown that the 18 months of Covid purdah was a perfect opportunity for wholesale, root and branch redevelopment of the comms industry's entire working philosophy. Everything was up for grabs because big changes had already taken place.

In this mood for a thoughtful upgrade, software engineers were in the driving seat. Working practices, team dynamics, re-investment priorities, even career aspirations were all available for change. Re-coding to adapt to that new reality was the easiest of the changes on offer.

ABOVE Traditional voice telephony hasn't kept up with the times

"Where were the new features, the transformative breakthrough gadgetry?"

Which leaves me quite disappointed in both trad copper phones and business VoIP presenters. Where were the new features, the transformative breakthrough gadgetry, the free market in third-party add-ons? Remember, the headcount of coders inside comms companies is phenomenal. Tens of thousands of people, all working on stuff that didn't change the experience of customers making phone calls.

Why so many? Because it all goes into trying to save money on the infrastructure side of the operation. In the UK, we're not used to thinking about this secret army toiling away, because most of us grew up with a monolithic telephone service. From the perspective of the dev team within a backbone carrier, the priority is the kind that intelligently routes your call packets through the cheapest connection. Devs treat non-international and international connections just the same, so even when the call completes totally inside a national boundary, it's still subject to the same smart link choice and cost-reduction imperatives, as if you were calling from Knightsbridge to the Ministry of Mines in Namibia.

Why dig up an old fossil like this? What relevance does it have in the modern world?

Because it exposes the way that phone carriers can interfere with a call passing over their connections. Intermediating carriers, as a business sector largely hidden from Joe Public, have absolutely exploded in the last couple of decades. Simply reaching a mobile phone from a landline involves passing through privileged connections that present little strangenesses, such as my contract phone inserting "bundled call"

Double-o, double-o: an early harbinger of modern-day telephone woes

My aside about calling from Knightsbridge to Namibia isn't a fairy-tale reference. After setting up a growing consultancy business in a 1960s tower block – its musty ambience should have been the canary I mentioned – it wasn't until we had a few international jobs on the books that the hidden downside of our cheap office space emerged.

We had our own phone system, and the supplier had told us the building was fed "only by Mercury". We thought nothing of it, until the Namibian job started snagging on us. We could call them; they couldn't call us.

Because there's essentially zero diagnostic information for voice calls – then or now – it took a bit of experimenting and a flight to Namibia to get to the bottom of this problem. Our number at the time ended with "0000". It turned out that almost none of the telephone packet routing counterparty agreements of that era expected to see a UK phone number that ended with four zeros. When it was shown the number, the software making the multi-carrier, complex international path reacted by dropping the connection. Ringing, but no sound.

We absolutely loved our unusual number, referring to it as "double-o, double-o" rather then the more prosaic "four noughts". Little did we know the penalties this would incur out in the wider world.

A passing irony here is that Mercury was a unit of Cable & Wireless. It is impossible to overstate the importance of C&W in the specific field of connections between disparate phone companies, and managing the whole telephony function in lots of former British Empire territories. For one part of C&W to sell us a company phone number that another part couldn't route correctly was a harbinger of things to come for the whole industry.

announcements just before the mobile device opens the audio channels.

Having your call passed around multiple call centres involves a different set of connections again; as you might expect, a call doesn't do well if it follows the same routing path when talking to a service a couple of towns away as it does to one thousands of miles away. The trouble is that reaching your SIM issuer's "preferred" mobile phone partner means it takes a different route, one dictated by cost rather than your convenience. While this looks like a technical design issue, it's also subject to the state of negotiations between the last-mile old-school physical phone company and the cloud-resident, virtual bandwidth reseller.

The Brexit effect

Then we come to Brexit. Our exit from the EU has changed the relationship between UK and European phone networks, and this means that eccentric behaviour over long-haul connections has started to intrude on all manner of phone connectivity. There's no winner between hallway-mounted Bakelite home phones and zippy, leading-edge, VoIP-powered virtual handset apps: all of them must traverse the same mixed network of internet connections and antediluvian, planetary-infrastructure-level phone trunks.

Even mobile phones have their quirks. In some cases, depending on where you are and the number you're calling, the intermediary network handling your roaming connection can request 25 quid from your online account – and not complete the call unless the money is in their hands. While the money is mostly returned when you hang up, it really does leave your account before you get audio-connected in the call.

These networks are multiplying on us, in a field we can't normally see or interact with, validate or complain to. All that time spent in back bedrooms during 2020 and 2021 has given us a splurge of monitoring software for all manner of services and systems. The rule seems to be that the less important the system, the more comprehensive the monitoring. I know more about the round-trip time to cloud-based game servers than I do about the route taken and charges levied by voice calls coming in to my phone while I'm abroad. My graphics card fans are watched at sub-second sampling rates, my Apple NVMe SSD lifetimes are unearthed by an app called Sensei, but hell will freeze over before I can have a live report of the path taken or costs incurred by a live person-to-person phone call.

My major priority is getting some debugging information when an apparently "regular" phone call fails to work correctly. Being told by a non-specialist infrastructure person that it might be time to get a new phone or that it must be my battery is galling when I can demonstrate the routing issue simply by having a spread of SIMs and phones here – but the other attribute of corporate and healthcare use of telephony is that you don't get to call them back.

Then there are the spam calls – the ones that want to pretend they're in Basildon, not Bangalore. We already have cloud-connected firewalls that can refer to central blocklists of IP addresses with a history of malicious traffic, but our phones are open for any Tom, Dick or Harry to call.

Seriously, phone technology people: it's 2025. Would it genuinely be that hard to expose an API or two and let the world's developers loose on their own call data? I bet you'd get a ton of positive vibes if you awarded a "Best monitoring app" prize. I'd even volunteer the entire *PC Pro* team to act as judges for you, just to see a bit of progress with this idea.

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Empires of telephony

You may expect me to deliver a league table of VoIP applications at this point, but I'm not going to break it to you gently: I have no such thing, because VoIP is neither the problem nor the solution for this issue. If anything, it's the broader programmability of VoIP telephony that allows malicious operators to masquerade behind apparently domestic numbers, facilitating the most distressing forms of scamming.

It's SIP, not VoIP, that's used in internet telephony. Session Initiation Protocol is one of those annoyingly early protocols that nobody seems able to improve on. The reality is that the successful modern telephony-substitute apps don't use the old protocols. Battling with SIP transformations in firewall rules has defeated many a phone upgrade project, while WhatsApp, Skype, Google Chat and even Facebook all succeed seamlessly. Am I the only person who uses Facebook audio as a social media answering machine, leaving friends and family voice messages in Messenger?

That's great if you're only ever calling or called by your friends. And I concede that there really are sectors that function this way, for whom new customers are passed along by existing contacts.

While we may whinge about the distraction and irrelevance of VoIP and SIP, at least they represent some kind of attempt at inter-operator compatibility. The various internet telephony providers all take the view that if you want grandma to be able to join in your online family gathering, she'll just have to bite the bullet and become a member of the same voice platform that you're using. All those providers think this is a great way to capture market share from one another, because there's no better salesman than one right inside your friends and family, right?

Actually: no. We would all have had a very much easier ride through the whole lockdown thing were it possible to import calls across disparate voice/chat/conferencing platforms. All it would have taken was a little burst of software development, this time by the newer generations – but no, once again, the dream of interoperability was discarded in favour of hoping for short term gains from impatient users.

In voice communications, nothing moves without some giant corporation seeing some revenue-positive benefit from it. So we still see calls from WhatsApp to a roaming 4G or 5G smartphone having to go all the way "down" to a telephony gateway and then across several private networks, before coming "up" at a service border router to hopefully find its way to the right internal account identifier.

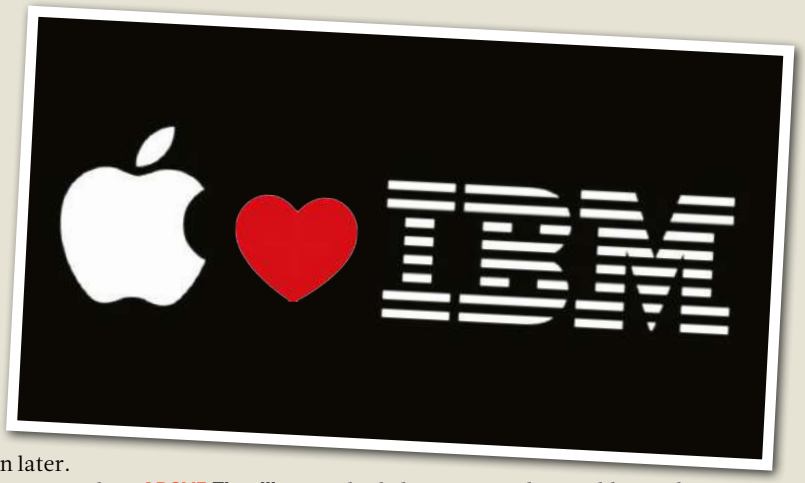
And people wonder why the sins of the old wires-and-dials, chugging Strowger-machine-based phone networks have been carried over to a world that leaves us trying to call people back, dropping the line and a dozen other stupid phone tricks that should have been consigned to history decades ago. Simplification is long overdue.

ABOVE Modern telephony providers have baulked at the idea of inter-operator compatibility

BELOW Everything is monitored to the max on my MacBook – unlike my phone calls

Apple's big blues

Apple once joined forces with IBM to create a new operating system that could easily have destroyed the Mac. David Crookes explains what happened



ABOVE **The alliance between Apple and IBM was intended to create a single unifying platform**

In the late 1980s, Apple embarked on one of its most ambitious software projects: the creation of a next-generation operating system, codenamed Pink. Presented on a pink index card (hence the name), it was the brainchild of a small group of Apple engineers who believed the Mac needed memory protection to safeguard users' work in the event of a system crash. This innovation also helped to pave the way for an alliance with IBM that had the potential to revolutionise computing forever.

Around 1988, the Mac was experiencing a period of flux. Launched in January 1984, it had initially achieved success but most of the computer's original team members, including Steve Jobs, had dispersed and cracks were beginning to appear. While improvements had been made to the Mac line-up, such as the introduction of colour graphics in the Macintosh II in 1987, it became clear that a new operating system was necessary to replace Macintosh System Software sooner rather than later.

"The classic Mac OS was increasingly difficult to work with," said Mark Davis, who would become the manager and architect for the proposed operating system's international frameworks. "The original Mac had such constraints of speed and size that the OS was written all by hand in assembly, and the structure was very difficult to maintain and extend."

Initially, only five people worked on Pink – the so-called Gang of Five who had proposed it. Project leader Erich Ringewald was joined by David Goldsmith, Bayles Holt, Gene Pope and Gerard Schutten. This small team had also presented two additional sets of goals for consideration, each represented on a different coloured index card. Red proposed an operating system with far more advanced features such as speech recognition, while Blue concentrated on short-term achievements that could be integrated into the Mac.

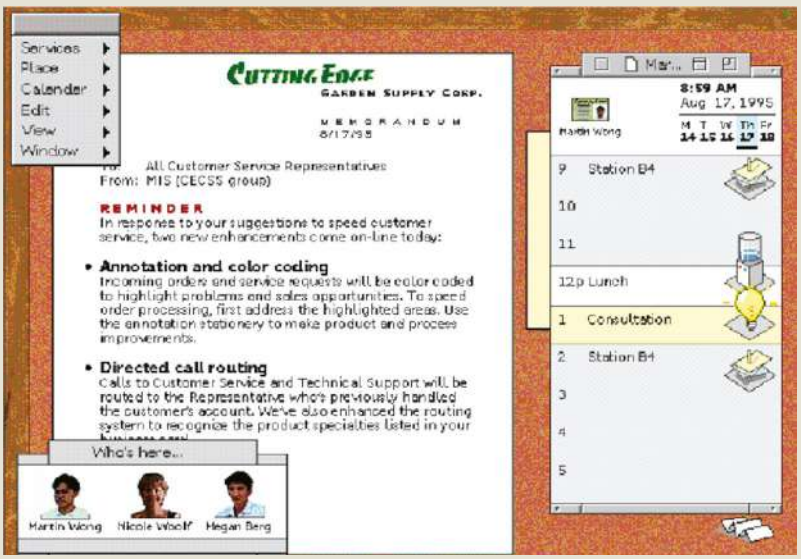
Pink, however, stood out as the most significant development since it was forward looking and achievable, especially since the OS was being developed during a period when Microsoft Windows was enhancing its capabilities and IBM had launched a promising competitor called OS/2.

"Pink had the promise of leapfrogging Macintosh System Software, Windows and OS/2," said Davis, who stressed the software was created 30 years ago.

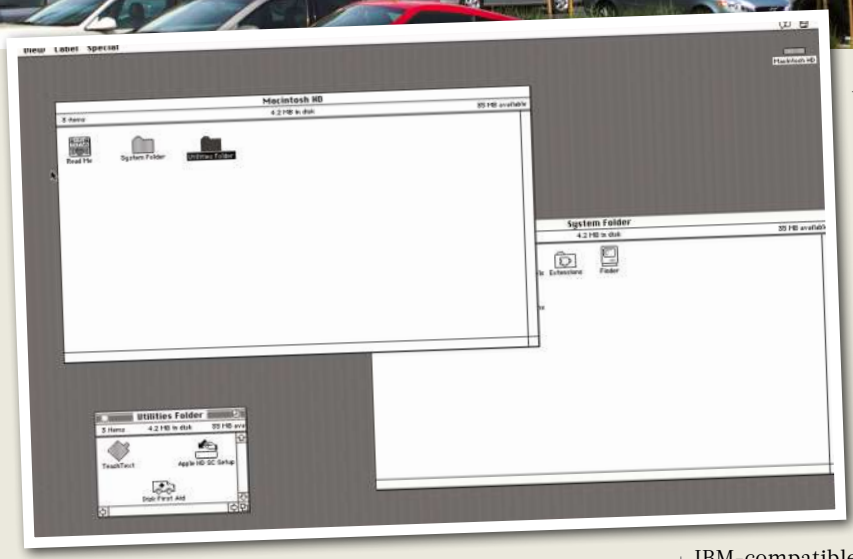
"Pink evolved into an object-oriented operating system written in C++, which was a relatively novel concept at the time"

All systems go

When the engineers began work in March 1988, their key priorities were memory protection and multitasking, with the OS set to be built using legacy System 6 code. Within a few weeks, Pink evolved into an object-oriented operating system written in C++, which was a relatively novel concept at the time. This approach made the OS more adaptable, future-proof and easier to update, manage and build upon.



LEFT **There are very few screens showing the Pink/Taligent OS**



Moreover, the engineers believed it would make life easier for app developers, encouraging them to create more software for Apple computers. But it was also clear that the task of creating the new OS was going to overwhelm a five-person team. Recognising this, a separate team was assembled to create a kernel that would provide memory protection and prevent crashes. Within a couple of months, 25 people had joined the Pink project. But this influx of talent also brought new challenges.

By October, Ringewald, Pope and Shutten already felt the project was spiralling out of control and they left, concerned their goals wouldn't be accomplished. But Apple believed that Pink had the potential to have a positive impact on the company, so investment continued and the features continued to stack up.

"Off the top of my head, Pink had modern frameworks, a powerful graphics system and it was fully Unicode/internationalised," Davis said. Yet when anyone asked when Pink was due to be released, the answer consistently seemed to be "two years".

Another bite

By 1990, 150 people were working on Pink, either directly or as support staff. A marketing team was even in place, despite the operating system remaining far from completion. By this point, Pink was going to replace the Mac operating system rather than enhance it – its growth had made a fresh start inevitable.

"In order to make that happen – while maintaining the classic Mac OS during the Pink development and deployment – Apple needed partners," Davis said.

External assistance came in the form of IBM. In the second half of 1991, Apple and IBM formalised an alliance that executives told the *New York Times* would "change the landscape of computing in the 90s". Its primary aim was to "use common chips and common software in an effort to gain control of two key technologies," the report continued.

The Apple-IBM alliance went beyond simply assisting with Pink. Both companies would collaborate on developing RISC technology for a new PowerPC microprocessor with assistance from Motorola (Apple insisted the latter was brought on board so it wouldn't be reliant on IBM for processors). They would also work together on the development of multimedia and interface technologies in a partnership called Kaleida.

Pink would be subsumed into a new company called Taligent ("I was the head of the internationalisation and text group with the responsibility of making it easy to produce apps that could handle any language," Davis said).

The intention was to create a single unifying open-standard computing platform that could compete against the combined power of Microsoft and Intel. As part of the deal, Apple would become a prime customer for the new chips and IBM would benefit from Pink, which was also earmarked to work on Intel-powered computers.

With Apple's market share down by around 50% in the late 1980s as it competed against more affordable IBM-compatible PCs, the deal made sense. Allowing Pink – or Taligent or TalOS, as it was becoming known – to be used on other computers was also attractive. This strategy had proven successful for Microsoft, after all.

TOP **The Taligent HQ on the Apple Infinite Loop Campus, Cupertino**

ABOVE **Apple's successful System 7 OS was based on the Blue goals**

Seeing stars

Pink had made significant progress by this stage. Apple's CEO John Sculley said more than 1.5 million lines of code had been written, indicating that it wasn't that far from completion. "As I recall, it was fairly far along at that point," Davis agreed, although he admits his memory of Pink's transition to Taligent is "very fuzzy".

The Taligent reins were handed to an IBM person – Joe Guglielmi, who was previously the general manager of marketing and business development for the company's Personal Systems Line of Business. He believed in the future importance of object-oriented technology and he told *IBM OS/2 Developer* magazine that "since we're writing an operating system from scratch, we get to do some things right".

"Apple would become a prime customer for the new chips and IBM would benefit from Pink"

But in 1993, there was a change in strategy. "Initially, the notion was to deliver one large, brand new

Images: JKoheiKanno, Wikimedia Commons, CC BY 2.0

operating system, top to bottom, in one really significant drop," Guglielmi said. "We've become more realistic about that; we've had to deal with very pragmatic issues." Rather than release a single OS, those working on Taligent looked to take pieces of their operating system and make them available to others such as IBM's OS/2 and AIX and Macintosh System Software.

"This isn't 1983 any more," Guglielmi said. "This isn't about 'I have a great technology; we'll just get people to stop what they're doing and move over to it'. We have example after example in the marketplace today where great technology can't get commercial acceptance."

It seemed rather unorthodox – to help make other operating systems competitive through evolution so that introducing Taligent as a whole wouldn't be a big step up. But it ensured there was still some life left in Windows' current crop of rivals; which was just as well because, while work continued at Taligent, Apple shipped System 7, created by a team that had been following the Blue goals laid out three years earlier.

The latest release of the classic Mac OS operating system included QuickTime, virtual memory, drag-and-drop, TrueType fonts, a Force Quit dialog, balloon help and personal file sharing. It was two years behind schedule (the initial work having only been envisaged to take a year), but it was very impressive, giving Microsoft a run for its money until the launch of Windows 95.

The Mac killer?

Apple had hoped IBM would shoulder a significant portion of the costs associated with developing Taligent. But the persistent issues that plagued Pink, particularly a lack of focus, were damaging Taligent. Some 350 people were employed at Taligent a year after its formation, a substantial increase from 160, and that was causing problems.

"I think the biggest challenge in hindsight was managing the project, keeping it from being forever in development," Davis said. "One policy had a horrible impact; people working at lower levels of the project would make incompatible changes and it was up to everyone else on the project to rewrite their code."

In one sense, Taligent's ongoing drama was working in Apple's favour. In 1993, an article in *Wired* magazine discussed the wider implications of a successful Taligent, claiming it would effectively kill both the Mac and IBM's OS/2. If the new operating would work across different computers, whether PowerPC or Intel-based, what would be the attraction of the Mac?

"Realising that the Macintosh can never prevail against the dominance of Intel-architecture systems, Apple is gradually phasing out the Mac," the article said, pointing out that 92% of large corporations were intending to use the Pentium and 486 chips manufactured by Intel.

Taligent had the potential to supplant Windows whereas Apple's own OS did not – indeed, an attempt to port Macintosh System 7 to Intel-compatible PCs (the Star Trek project) had just been canned after a year in development. But the longer it took for Taligent to be developed, the more disinterested the wider computing world was becoming. And this, in some ways, saved the Mac.

In fact, Apple's alliance with IBM required it to develop future ranges fitted with PowerPC chips, but these wouldn't be compatible with the Mac's operating system as it was. So Apple released System 7.1.2 in 1994 – the first Mac system software for Power Macs – and the PowerPC range continued until 2006.

A brighter future

Still, Taligent had clung on for some time. Hewlett-Packard bought a 15% stake in Taligent in 1994, adding credibility, yet more and more users appeared happy backing Windows 3 and Windows 95. As the months rolled by, Taligent seemed less likely to succeed.

"Joe Guglielmi left suddenly [in September 1995] and his replacement Dick Gurino died suddenly very shortly thereafter," said Davis. "It all unravelled as a joint venture thereafter."

It certainly did. In December 1995, Apple cut its losses and dissolved the project. As a result, half of Taligent's 400 staff were made redundant and Taligent formally ended in 1998.

IBM absorbed most of Taligent's assets and integrated some of its innovations into its own software. Notably, parts of the OS were used in IBM's Workplace OS prototype, and a layer called CommonPoint made up of more than 100 object-oriented frameworks was released. It lay on top of operating systems such as OS/2, AIX, HP-UX and Windows NT.

"Although Taligent was ahead of its time in terms of design and capabilities, it was also ahead of its time in terms of hardware requirements – too far ahead," Davis said.

And yet that proved to be blessing. Had the Taligent part of the alliance worked out, there was a good chance IBM would have taken over Apple. As detailed in the 1997 book, *Apple: The Inside Story of Intrigue, Egomania and Business Blunders*, the two companies were looking to see how well they worked together and a potential deal was on the cards.

Sculley believed Apple needed a company to acquire it because he couldn't see how it could continue alone. Had a takeover happened, it would have created a force to be reckoned with but, with hindsight, the consequences would have been profound.

Jobs is unlikely to have returned to Apple, bringing with him the NeXTSTEP operating system which formed the basis for the future of Mac OS and in effect saved the company. Apple's subsequent rise is also unlikely to have happened, and there's a strong chance we wouldn't be holding an iPhone or iPad today unless Jobs had taken his talent elsewhere.

So while the collapse of the Taligent side of the IBM deal wasn't ideal, it worked out for the best. And the alliance did have an impact. Its legacy included the push towards reusable, modular code and the development of the PowerPC CPU architecture. With both Apple and IBM also in great health today, there can surely be no real regrets. ●

News

HP bets on Taligent

Cash infusion, technology exchange may aid object-oriented developer

By Melinda-Carol Ballou

Hewlett-Packard Co.'s disclosure last week that it will purchase a 15% stake in Taligent, Inc. and use the latter's object-oriented development environment with its Unix operating system could help boost the IBM/Apple Computer, Inc. joint venture's prospects in the emerging object wars.

"From the user's point of view, they don't know what Taligent is going to look like, but every partner [Taligent] can add gives them credibility," said Brent Williams, an analyst at International Data Corp., a consulting firm with offices in Mountain View, Calif.

Even with HP, Taligent has its work cut out. The company faces opposition from Sun Microsystems, Inc., which recently announced an alliance with Next Computer, Inc. [CW, Nov. 29], and from Novell, Inc. with its AppWare environment, and Microsoft Corp. with its Microsoft Foundation Classes (MFC), distributed Object Linking and Embedding (OLE) and Cairo.

Taligent officials claim that its Application Frameworks, which will begin shipping in stages during the first half of 1994, will enable developers to more easily create, reuse and maintain code [CW, Nov. 8]. For instance, while MFC offers class libraries to ease Windows development and OLE offers interfaces to enable developers to share data, OLE is arcane and difficult to use.

"We have over 100 frameworks, each with its own class libraries, and because of their comprehensive design, a developer will get the functionality of other frameworks — such as real-time, [two- or three-dimensional] graphics, compound documents or international text and line layout — without having to create it separately," said Scratton Selavos, vice president of marketing and sales at Taligent.

Using Taligent, developers will also be able to "write an application once, and it will be able to run across multiple operating systems from Intel to RISC to PowerPC," said Joe Guglielmi, Taligent chairman and chief executive officer.

But talk is cheap. Taligent's technology is not commercially available yet, and MFC and OLE are already well-established in the market, with about 135 independent software vendors committed to shipping OLE-compliant products by June.

Aiming at Windows

Other analysts said that given Microsoft's ubiquity, Taligent must come up with an effective way to target Windows. Taligent officials said they will do just that and that they expect to support Microsoft's 32-bit operating systems, such as Cairo and Chicago, when they ship, as well as Windows clients.

HP's infusion of cash will be helpful but more significant, according to industry analysts, will be a technology exchange between the companies. Taligent will license HP's Distributed Object Management Facility (DOMF) and components of HP's Distributed Computing Environment/9000.

HP and IBM last year announced a deal to integrate DOMF with IBM's System Object Model (SOM) and distributed SOM. Taligent will incorporate both. Taligent will also standardize application programming interfaces (API) for its Application Frameworks and establish a licensing and certification program with X/Open Co. to make the APIs available to third parties.

Under terms of the HP agreement, which had been expected [CW, Aug. 16], Taligent will issue new shares of its stock to HP. Financial terms were not disclosed. HP will also take a seat on Taligent's board of directors.

West Coast bureau chief Jean S. Bozman contributed to this story.

Taligent CEO Joe Guglielmi *claims Taligent will offer developer flexibility*

ABOVE Taligent attracted much press coverage in publications such as *Computerworld*

"Had the Taligent part of the alliance worked out, there was a good chance IBM would have taken over Apple"

BELOW The alliance helped lead to the development of the PowerPC CPU architecture

Images: Pippinitis, apple.fandom.com/wiki/Taligent

Futures

We explore the trends and technologies that are set to shape the future

AI agents: putting AI to work

This year is set to be all about AI agents. Nicole Kobie reveals what this means and whether the backlash is beginning before AI agents are even here

"Hey, assistant! I sent you a link to a form. Can you dig out the sales figures from last month in order to fill it out? I'll be at lunch, so message me any questions."

Such dull jobs used to be saved for junior staff and interns, but soon AI may be taking them on – well, that's the promise of AI agents, according to those developing the smart automation tools.

It's high time for AI to start proving useful, as various surveys suggest a third of businesses continue to be too scared of the risks to consider implementing the technology (Indeed), seven in ten employees aren't convinced it makes them more productive (Resume Genius), and a Goldman Sachs report suggested the benefits remained too little given the costs.

That's why AI developers – Google, Microsoft, OpenAI and Anthropic, among others – are beginning to release details about their own AI agents, sparking predictions that the digital helpers will be the big story in 2025. Microsoft and Anthropic have already launched agents, Salesforce believes its customers will have a billion agents in use by 2026, and OpenAI chief product officer Kevin Weil said in October: "These more agentic systems are going to become possible, and it is why I think 2025 is going to be the year that agentic systems finally hit the mainstream."

But warnings are already sounding on security risks, poor performance and employee trust, while analyst house Gartner says there's a risk that companies will be overwhelmed by agents that no-one can remember the purpose of – similar to the problems raised by creating too many bots in robotic process automation.

The AI industry seems dead set on making this pivot to agents, so here's what we know, how it will impact you, and how they're already being used.

AI agents vs agentic AI

So what is an AI agent or agentic AI? Well, that depends who you ask. Some see the idea as merely letting AI loose in the real, if digital, world, with software that can read documents, type text and click links. Given that's what many of us spend our working days doing, giving a large-language model such skills could mean the technology gains real capabilities.

Others believe that AI agents should have, well, agency – or at least the ability to make decisions. Arguably, if a piece of software needs to read a website, understand that information, and apply it when choosing which button to click, that could be seen as making decisions.

Krishna Tammana, chief technology officer of customer engagement developer Gupshup, explains that agentic AI is different from conventional, narrow AI that may be designed for specific tasks and require plenty of human oversight or intervention. AI agents have autonomy and context, extending their powers.

"Agentic AI is a type of AI that operates autonomously, capable of pursuing complex goals and workflows with minimal direct human supervision," said Tammana. "At its core, agentic AI aims to function similarly to a human employee by understanding context and instructions in natural language, setting appropriate goals, reasoning through subtasks, and adapting its actions based on changing conditions."

There are some who differentiate between AI agents and agentic AI. "We see agentic AI as an autonomous decision-making capability that can act independently within defined parameters, allowing enterprises to delegate operational decisions that do not need oversight but still prioritise ethical standards, data integrity, and security," said Manoj Chaudhary, CTO of Jitterbit. "This approach ensures that businesses can achieve efficiency and innovation without compromising on accountability and control."

Chaudhary added: "AI agents, on the other hand, are task-oriented for predefined actions and follow specific user commands to automate workflow management, assist in complex development tasks, and provide real-time decision-making support. These agents offer immense potential to improve key areas of business process management with orchestrated oversight, including workflow automation, resource allocation and performance monitoring."

Now, it's worth noting that some in the industry are widening the definition of AI agents to include any form of automation or interaction, including chatbots and transcription. What's more, the idea of AI making decisions and doing things inevitably raises the spectre of artificial general intelligence (AGI) rising up to take our place as the supreme beings on the planet. But it's worth keeping a narrow definition of AI tools that can take action – otherwise, it's just plain old AI.

What's on the horizon

The big players all have equally big plans for AI agents in the coming year.

OpenAI's CEO Sam Altman has said that 2025 is the year that "agents will work", with the company showing off a demonstration of an agent making a voice phone call to place an order. A Bloomberg report said insiders at the company discussed OpenAI's agent plans at a staff meeting, suggesting the company plans to unveil its version called "Operator" in January 2025.

Microsoft unveiled its own first take on agents in Copilot in October, highlighting how early adopter customers used the tools to quickly develop bespoke automated tools to triage emails and track expenses. Charles Lamanna, CVP for Business & Industry Copilot at Microsoft, said that the tools can help augment business processes and workflows. "They're able to work on behalf of a system as opposed to a person, work asynchronously, or even autonomously to complete tasks," he stated.

ABOVE OpenAI's Operator agent is likely to be launched in early 2025

Anthropic, a rival AI firm formed by ex-OpenAI staffers, has already unveiled a very early AI agent as part of an update to its model, Claude. In a post on the Anthropic website, the company said that "developers can direct Claude to use computers the way people do – by looking at a screen, moving a cursor, clicking buttons, and typing text". However, the company added that the "computer use" tool is still experimental – and prone to errors.

"We see agentic AI as an autonomous decision-making capability that can act independently within defined parameters"

What's next? Gupshup's Tammana is bullish on the potential progress for AI agents. "The trajectory of agentic AI will see rapid advancement, with increasing sophistication expected in the next 12-24 months," he said. "While not yet perfect, these AI agents represent a transformative technology that is progressively becoming more reliable, versatile and integral to complex problem-solving across industries."

As always, we'll have to wait and see how far these tools develop, but with AI agents such a clear focus for the industry we can be certain that plenty

of money will pour into development. With so much competition, we expect progress to be rapid.

How could we use agents?

We keep being promised that AI will take over the dull, routine tasks that prevent us from digging into the creative, interesting bits of our jobs. By linking company data with an LLM in an organised way, an agent can do this – or at least some of this.

"By automating routine cognitive tasks, these technologies dramatically reduce operational costs, enable faster decision-making and allow human employees to focus on higher-value, creative work," said Gupshup's Tammana. "Companies can leverage AI agents to process complex data sets, generate comprehensive market analysis, develop sophisticated predictive models and create strategic recommendations with speed and precision previously unattainable."

The use case for AI agents naturally differs by sector. In healthcare, Tammana says, such agents could continuously watch patient data to recommend interventions, while in financial services, AI agents could be set to work in fraud detection, looking for unusual patterns of behaviour. In HR, AI agents can sift through CVs, schedule interviews and even conduct first-pass assessments, while in retail such tools can offer personalised recommendations and manage inventory.

AI agents at work – now

Andrew Filev, CEO and founder of Zencoder, says that boring, mundane or administrative tasks are good candidates for agentic AI – and that includes some, but not all, aspects of software engineering. "For example, when engineers create software systems, part of their work is highly creative, part is intellectually hard, and part is quite routine. In any large project a lot of engineering time goes to routine bug-fixing and maintenance, which consists of fixing a lot of smaller issues."

Filev says that AI coding agents can already handle between 5% and 10% of those smaller issues, predicting that will increase above a quarter by the end of 2025. That can be further extended to another 60% of smaller issues by breaking those down into smaller tasks, guided by human feedback, he adds.

To be clear, that means the vast majority of routine coding work such as bug fixing and maintenance could in theory be partially automated, but not the rest of coding. That doesn't mean software engineers will lose jobs.

"Most software companies go through a painful budgeting process, where they have to cut a lot of features from the roadmap because of the resources required to fix the bugs and maintain existing solutions," Filev said. "In my decades of experience, I have never met a software company that didn't have to prioritise the features and cut something out. AI coding agents have the potential to offload some of the bug-fixes, allowing the companies to execute on more of those innovative ideas, which would make user experience better, developer experience better and the company more competitive and innovative."

ABOVE AI agents can help in areas such as HR and software development

That's coding. Peter Wood, chief technical officer at Spectrum Search, says the company recently started using an AI agent in recruitment, in particular for data-heavy tasks such as analysing trends and matching candidates to roles. "It's all about cutting through the noise – things that would take a person hours, or even days, to process, this little marvel can handle in seconds," he said.

Rather than buy in a solution, the company opted to build its own – and it took time. "Testing it was like teaching a very clever toddler – lots of patience and trial runs with anonymised data," he said. "We started small, ironing out quirks before gradually introducing it to the wider team."

Wood adds that there was initial pushback from human employees. "Honestly, there were a few raised eyebrows from staff at first – who wouldn't be wary of a robot 'helper'? – but when they realised it wasn't there to nick their jobs, just make them easier, it won most people over."

There have been challenges, including edge cases that Wood says "stumped the system", but overall the AI agent has improved the speed and accuracy of dealing with customer requests.

Be wary

Those examples highlight some of the upsides. And there are downsides – beyond the obvious one that many of these claims and technologies remain largely unproven and unverified, especially beyond the tech-savviest of companies.

"For anyone considering AI, I'd say this: it's not a magic wand. You still need strategy, training and a clear purpose," Wood added. "Oh, and don't skip the ethics. AI is powerful, but making sure it's fair, unbiased and respectful of privacy is non-negotiable."

"Data privacy and security are crucial considerations, as AI agents may have access to sensitive information," agreed Zencoder's Filev. "Proper governance and ethical guidelines must be put in place to ensure that AI agents are used responsibly and do not cause unintended harm. Additionally, companies should invest in training and upskilling their employees to work alongside AI agents effectively, rather than viewing them as a replacement for human workers."

Implementation won't be easy. And though a bespoke AI agent may work well for a software developer, it could be beyond the capabilities of a small marketing boutique. And these systems aren't cheap, so keep a close eye on promises about return on investment. All of that means that AI agents may not be for everyone.

"Practical challenges include the complexity of integrating agentic AI into existing enterprise systems, which can be time-consuming and technically demanding," added Tammana. "The computational resources required for training and running these advanced systems can also be prohibitive for some organisations."

"Don't skip the ethics. AI is powerful, but making sure it's fair, unbiased and respectful of privacy is non-negotiable"

If a bit of investment saves your staff time and frustration, AI agents may prove worth it. If they initially prove more trouble than they're worth, you'll be glad to have waited for the second wave of AI agents.

So when it comes to AI agents, although AI leaders are saying 2025 is the year they go mainstream, patience may be a wise move. Though marketing materials and business consultants will urge companies considering AI agents to act now to avoid being left behind, it's worth watching to see how these technologies actually play out – and whether they pay off.

In the meantime, maybe keep the intern around. ●

Next month

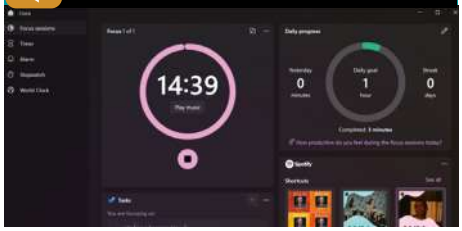
ON SALE
Thursday 6 February 2025

Features

Best products of 2025!

CES in Las Vegas gives manufacturers a chance to show off the gizmos they'll launch in the coming year. Jon, Tim and Barry are there to pick out the trends and products that matter.

Features



Take a break with Focus sessions

If you want to be more productive, you need to kill distractions dead. Nik Rawlinson takes a close look at "Focus" features in Windows, Ubuntu, macOS and our phones.

Features

Deep dive: video standards

H.264? MKV? ProRes? Darien Graham-Smith demystifies the video jargon – and explains which formats and settings you should be using.

Labs

Security suites

We have three aims with this group test. First, to reveal who offers the best all-round protection. Second, the best free antivirus choice around. And third, which paid-for security suites are actually worth coughing up for thanks to genuinely useful extra security and privacy tools.

Retro

Go modern on retro hardware

We admit that running Windows 11 on an Amstrad CPC could be tricky, but it is possible to use modern software on retro machines. We explain how enthusiasts are adapting 2020s code to 1980s hardware.

The Network

Network-monitoring software

Predict and fix failures before they happen, and keep your business working smoothly, with the best network-monitoring software around.

Futures

Live in the future, now

It's 2040. We all have robobutlers and virtual workspaces and only work two days a week monitoring our AI assistants. Sounds good? Nicole reveals how to live this life now! Probably.

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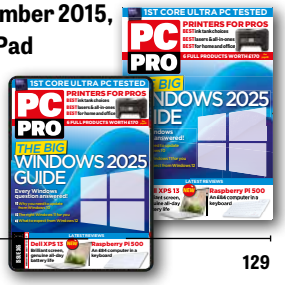

Ignore the hype around the Pi 500, says Jon Honeyball, and enjoy the hypermiling instead

It's called hypermiling in the motoring world: squeezing the most distance you possibly can from the minimum amount of fuel. This can be done as a personal challenge – my 12-year-old Audi A3 typically manages 50mpg on a decent run, so I was rather proud when I eked out 100mpg – but this pales against the true masters of the craft. Most famously, VW drove the XL1 100km on a single litre of diesel, which works out at 280mpg. And it managed this, albeit in a somewhat pricey and very limited production run car, over a decade ago.

In the computing world, we only used to think about absolute performance. There was never enough, and let's ignore the power consumption. Noisy fans were a sign of virility in the computing world; the higher the wattage of your power supply, the happier you would be.

Today, with the help of Moore's Law and greater environmental consciousness, we have moved on. Now I want maximum performance with minimal energy use. The crown appears to sit with Apple's quite extraordinary M4 family of processors, which offers eye-watering performance with power consumption that's almost laughably low.

But that's on a computer that, once you add in all the "extras" like screen, keyboard and mouse, costs a lot of money. It wins for efficiency after you've bought it, but for a computer to claim the hypermiling crown I think we need to bring the price into the equation. In short: how much is enough performance, and what's the cheapest way of getting it?

The classic approach is to buy an older computer and keep it running. That's good for the green credentials, but it's still going to be a compromised solution when it comes to capabilities, reliability and overall value. It's also not repeatable. I might get lucky with my second-hand computer; you might not be so fortunate.

So I welcome the new computing hypermiling king, the Raspberry Pi 500. This updates the already marvellous Pi 400 with a Pi 5 processor board, so you're buying a computer that includes everything you need built into the keyboard unit. Well, almost everything. Raspberry Pi has also launched a screen, the Raspberry Pi Monitor, which will do produce a perfectly reasonable 1080p image on its 15.6in IPS display. There's a fully adjustable monitor mount for this, too, if you want to lift it off the tabletop.

The cost? Well, the Pi 500 is £85, ramping up to an enormous £113 if you bundle in the USB-C power supply, a micro-HDMI cable and a 32GB microSD card preloaded with Raspberry Pi OS. The screen is £94. The Pi Monitor Stand is £14, which is something of a far cry from the £949 that Apple wants for the wonderful 6K Pro Display XDR. Apologies, I misspoke: for the *stand* for the wonderful 6K Pro Display XDR. Finally, the Pi Mouse is £7.50.

Call it around two hundred notes, including VAT, plus or minus a bit depending on whether you have a spare microSD card, HDMI cable or mouse.

And here's the dilemma. It's all you need for day-to-day home computing. I haven't looked at Pi as a desktop OS for a while, but last time's outing was very positive. A quick search shows that LibreOffice is available, which is free and does everything anyone actually needs in an office suite.

Frankly, it's all you need for most normal business computing, too, if everything runs in cloud services such as Google Workspace or Microsoft 365. You don't get the full integrated management stack of Microsoft's new Windows Link device (*see p33*), but I'm sure I'll have no problems locating an appropriate RDP client on the Pi 500 and thus have access to a fully cloud-hosted Window 365 session. And at approximately half the cost of Microsoft's CPU-only unit, I'll accept the loss of integrated management facilities of the local hardware.

If you're an SME, then, what's stopping you? Surely this is all the computing resource you need, and at both an energy and price hypermiling point that cannot be ignored.

Let me repeat the price point. It's two hundred notes, for a full-stack fully functional computing device with screen, keyboard and mouse.

> "Surely this is all the computing resource you need, and at both an energy and price hypermiling point that cannot be ignored"

Two. Hundred. Quid.

Of course, I'd rather use my new M4 Pro Mac mini attached to its Apple 5K screen. I'd rather have access to pro-grade tools such as the Adobe suite, Final Cut Pro, Logic Pro, full-fat Microsoft Office and every other bauble. But we must step back and ask: what do you actually need? And what price are you prepared to pay to get those additional capabilities?

Now that I've ordered a Pi 500, I'm tempted to give myself the task of using it as my daily driver. I'm not sure how long I'll last, given my reliance on advanced capabilities in Excel, but as a second screen on my desktop, and most especially as a computer in my work room at home, the hypermiling king will surely reign supreme.

Jon has been a contributing editor to *PC Pro* since issue one. He prefers "inexpensive" to "cheap". Email jon@jonhoneyball.com.

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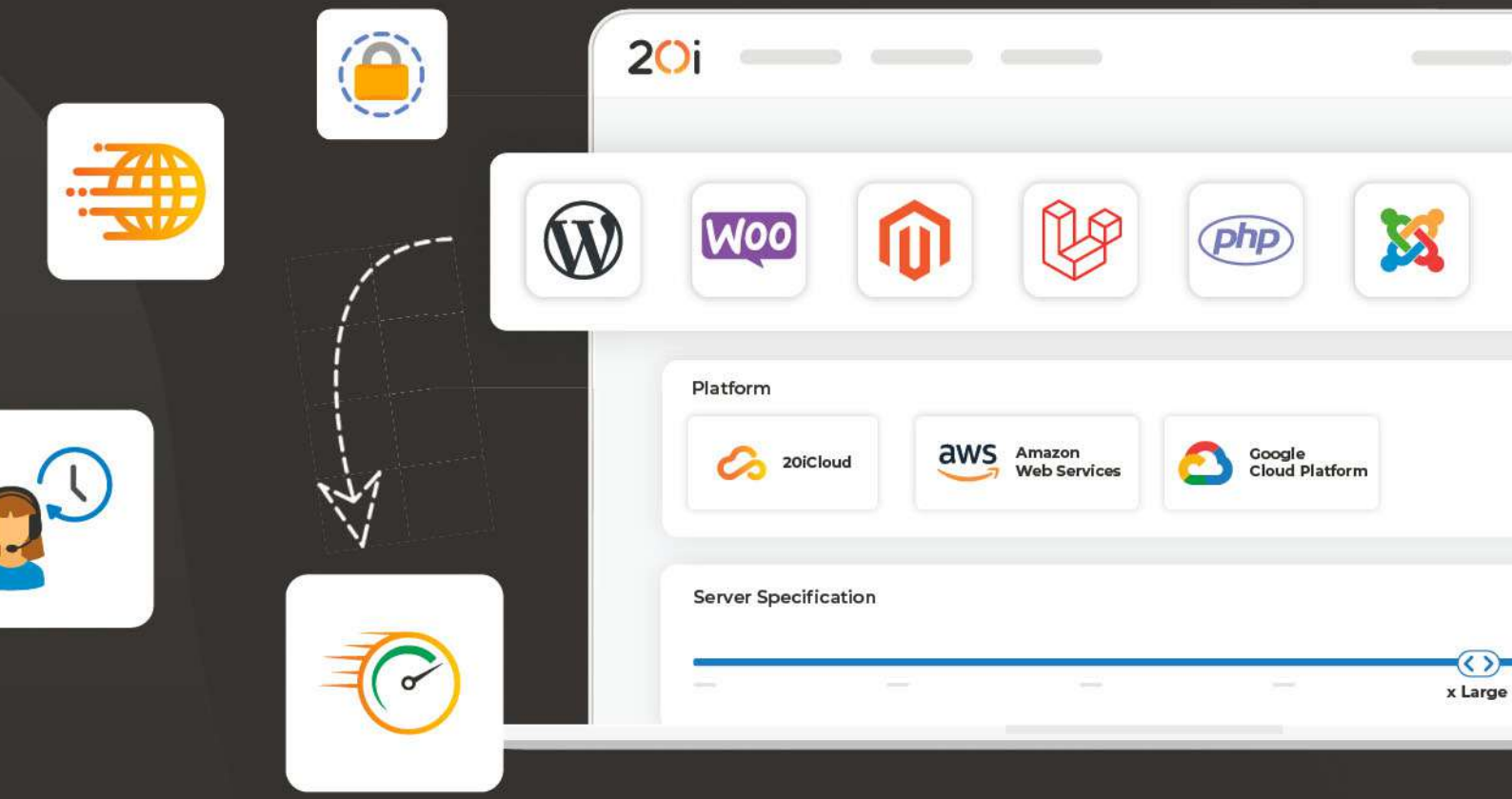

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